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1897.

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(Animal Product Series, No. 2.)

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THE

AGRICULTURAL LEDGER.

1897—No. 1.

PEARLS AND PEARL FISHERIES.

(SEED PEARLS.)

[*Dictionary of Economic Products, Vol. VI., Pt. I.,* P. 355-60.]

PEARL FISHING IN THE BASSEIN DISTRICT.

Further Report by the Deputy Commissioner, furnished through the Revenue Secretary to Government, Burma, together with correspondence relating thereto.

The following papers contain much additional interesting information on the subject dealt with in *The Agricultural Ledger No. 36 of 1896.* They are accordingly given as a supplement to that issue.

From the Revenue Secretary to the Chief Commissioner, Burma, to the Reporter on Economic Products to the Government of India,—No. 277-2F.—9, dated Rangoon, the 10th March 1897.

With reference to the correspondence ending with your letter No. 3112—191, dated the 7th October 1896, I am directed to forward, for your information, a copy, with five spare copies, of a Report by the Deputy Commissioner, Bassein, regarding the pearl fisheries in his district. The specimens referred to by the Deputy Commissioner are also forwarded by parcel post.

Register No. 8980.
,, 8980 a.
,, 8981.
,, 8982.

Endorsement by H. Thompson, Esq., *Secretary to the Financial Commissioner, Burma,—No. 846-2F.—21, dated the 24th February 1897.*

Copy of the following with the specimens referred to forwarded to the Revenue Secretary to the Chief Commissioner, Burma, with reference to his endorsement No. 594-2F.—16, dated the 28th October 1896.

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Endorsement by H. Thirkell White, Esq., C.I.E., *Commissioner of the Irrawaddy Division,—No. 139-4F.—8, dated the 6th February 1897.*

Copy of the following, together with enclosures, submitted to the Financial Commissioner, Burma, for information with reference to his endorsement No. 249-2F.—59, dated the 7th November 1896.

From Captain F. D. Maxwell, *Deputy Commissioner, Bassein, to the Commissioner of the Irrawaddy Division,—No. 358, dated the 1st February 1897.*

In continuation of the correspondence ending with your No. 5924-2F.—26, dated the 11th November, I have the honour to supply the following information concerning the pearl fisheries of this district—information which I have gleaned from men who have known these parts for many years and who have collected oysters for eating for a long time.

2. As regards the habits of the mussel, it lives on mud, sand, or on rocks. Beds appear and disappear either during or at the end of the rains—some say the former, some the latter. The more general opinion seems to be that they appear about November, when the water is getting salt. In the paper marked A I send some shells of the Placuna taken out of the river about 5 miles above its mouth on the 2nd January. The man who shewed me this bed informed me that the bed appeared last November. I pressed him as to whether the bed had not really appeared in the rains but that it was in November he knew of it for the first time. He would not allow, however, that the bed had appeared before November, and said that he was daily over the place during the monsoon and saw no signs of any oysters.

Register No. 8981.

3. As to the appearance, disappearance, and breeding of the oyster none of the Burmans whom I examined could give me any information on the subject. An answer to the question is, however, to be found in Theobald, page 124: "The young are hatched within the body of the parent and are discharged in cloud-like swarms of tiny creatures to seek each its own living. The embryos at first swim freely about, in which stage they represent the permanent condition of the Pteropoda, but soon dropping their filamentous organs of motion as tadpoles do their tails, they either attach themselves permanently to any convenient roosting place within their reach as Ostrea or Chama, moor themselves securely by a *byssus* or cable, like Pinna or Mytilus, or lead a free and roving life like Cardium or Unio." See also *Dictionary of Economic Products,* Volume VI., page 121, where the following passage occurs: "The molluscs possess locomotive powers and frequently disappear from certain banks and migrate to more favourable situations." The Burmans say that no bed is known to be in existence for more than six years. During that time the action of the sea either covers them up with mud, thus smothering them, or breaks them away from their moorings, doing them mortal injury.

P. 355-60.

PEARL FISHERIES.

4. The numbers to be found in one bed varies very much: sometimes many millions are found; at others only a few thousands. Sand appears to be the favourite bed, though mud is also appreciated. The oyster is also to be found on rocks, but not in such large numbers as on sand and on mud. This, the Burmans explained to me, because there is only a limited supply of rocky bottom, whereas the other two are practically unlimited in extent. I see, however, from *The Agricultural Ledger No. 36 of 1896* that the oyster prefers a muddy bottom—*see* page 5. The pearl is said to appear when the oyster is about three years old, that is to say, never before two years and never after four years. The pearls are very minute and require a microscope to see them, but a pair of sharp eyes can occasionally pick out the larger pearls. On enquiring why the pearls are so small, the villagers say that the pearl as it grows prevents the oyster from closing and so allows the mud and sand to get into the shell and thus to kill the oyster. You will observe from the shells sent that they are remarkably flat and that the smallest obstruction would prevent the oyster from closing. In many oysters that I examined I found three, four, and once as many as eight small pearls, and I am informed that sometimes as many as fifteen are found, but they are so infinitesimally small that it is extremely difficult to count them. When the larger pearls are found they are found usually singly.

5. The *modus operandi* of getting the pearls away from the flesh is as follows: The oysters having been collected are put into a large cauldron of hot water; they then open and keep open. The flesh is then scraped off the shell with a knife and thrown into a basin. When the basin is half full it is put in to the sun and the flesh allowed to decompose. After three or four days, when the flesh has more or less thoroughly decomposed, water is added and the whole mess stirred. The pearls being heavier than the decomposing and decomposed oyster fall to the bottom and are easily got out of the basin. The rest is then passed through a fine sieve, so that no pearl of even the smallest description shall escape. The only thing that appears to receive no consideration in the matter are the oysters. It is to be hoped that they do not long survive the hot bath; but on this point the villagers appear to be somewhat doubtful, saying that they have great tenacity of life and do not finally succumb until they have been in the basin some hours.

6. Oysters found on rocks, sand, and on mud produce very different quantities of pearls. I give the following figures for what they are worth — they were given me by men who had worked on all the different bottoms last year, so they ought to be fairly accurate and of some value: "Three thousand oysters found on rocky bottom produce R1 weight of pearls, 6,000 from a sandy bottom and 40,000 from a muddy bottom produce the same weight of pearls." My informants were unable to explain this great difference, and I am unable to offer any reasonable suggestion unless the following may be considered worth anything: At page 127 of Theobald it is stated that pearls are "merely a deposit of the lustrous lining material of the shell round some foreign and offending object."

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This view is now apparently disputed, if not exploded. See the following from *Dictionary of Economic Products*, Volume VI., page 118 :—

> The popular notion that the foreign matter is generally a grain of sand is untenable. According to several eminent conchologists it is in most cases a minute parasite, but Dr. Kelaart believes the nucleus to be in most cases at least an ovum or ova escaped through the distended coats of an overgrown ovary and become imbedded in the interstices of the mantle. "I have repeatedly examined seeds or young pearl," he writes, "in process of formation, and with a magnifying power one-fifth of an inch lens I was able to see distinctly the outlines of two or three ova through the first or superficial layer of nacre surrounded by groups of ova." His theory is further supported by the fact that pearls are most frequently found imbedded in the mantle "near the hinge (the place where the ovarium is most likely to be liable to rupture) and by the fact that with careful examination he was generally able to find, when the pearls were not actually found in the interstices of the mantle near that locality, cicatrices on the structure where they once existed." The difference in the weight-producing capacity of the pearls found on different bottoms would seem to give colour to the popular belief that pearls are nothing more than "foreign and offending objects surrounded by the lustrous lining of the shell," but it is quite possible that the real explanation is something quite different.

7. The oysters were said in last year's report to be found in shallow water. This statement is, I find, only partially true. The oysters found last year were certainly found in shallow water, but I am informed that villagers have often found them in water at various depths—30 feet or more—so that if this is the case there seems no reason why they should not live in greater depths still.

8. I had about 300 oysters opened in my presence, and in each I found always one, sometimes two, small crabs. When only one it is the ordinary hard-coated grey type found on the sands ; when there is a second it is to all appearance a different kind altogether, a blue shell and very soft. It is possible that these crabs live parasitically in the oysters—*see* Theobald, page 128. It is noticeable too, with regard to the remark made there, that it is to the presence of these small crabs that the unhealthiness of the mussel is attributed, that the Burmans regard the oyster as very unwholesome ; but the reason they give is the presence of a minute worm found in nearly every shell. Even when this worm is extracted the Burman will not eat the oyster uncooked, though I swallowed several without feeling any ill-effects.

9. In paper marked B I enclose some shells exactly similar to those found in the river, but which are black inside. It may be

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thought that these are the same as those which are white inside, but I think not. The villagers say that the shells are washed up by the tide. I examined many hundreds of the shells taken last year by the lessee and did not find a single black shell among them. I also had six or seven men searching the heaps for a black shell but not one could be found. Perhaps the shell is a different variety of the Placuna and one found only out at sea and in deeper water than the white shells.

10. In *The Agricultural Ledger No. 36 of 1896*, page 5, an opinion of Doctor Alcock is quoted to the effect that the pearl fishery is not likely to interfere with the turtle banks, because the turtle prefer reefs and Placuna a muddy bottom. As to this I would remark that all along the mouth of the Thekithoung river, where Placuna are found in large numbers, the turtle known as *laitkwe* comes up to lay its eggs in the season from the month of September to that of December. If men were allowed to dive at night off the banks where the turtle come, I think there can be no doubt that the turtle would be scared away. It may be, and probably is, correct that turtle prefer reefs, but they do not by any means select the sands nearest the reefs to lay their eggs. If they did so they would not go up the Thekithoung river, but would remain out at sea and near Diamond Island. The turtle known as *laitpyintha* never come near the river but remain out at Diamond Island, whereas the number of *laitkwe* which lay there is very small. Out of 50 or 60 I saw on the island I only saw one *laitkwe*.

11. Regarding the remark of the same gentleman, that it is unwise to interfere with the poor people who collect Placuna, I think in future that in selling the right to collect oysters it should be stipulated that the villagers should be allowed to take what they want for their own consumption as the number they would take would be insignificant compared to the numbers taken by the lessee.

Probably 30,000 at most would supply the wants of the villagers.

12. In the paper enclosed and marked C I send some substance taken from the *osrea talienwahensis* from near Haingyi Island by a diver from 15 feet of water. The villagers call them pearls, but they do not answer to the description of what is generally understood by a pearl. Register No. 8980. „ 8980a.

Perhaps the Reporter on Economic Products would say what paper marked C really contains. *See next page.*

13. Theobald states, page 127, that the true pearl oyster is found all along the Arakan Coast. The lessee of that part of the district recently went up the coast with a view to working these pearl fisheries, but I have not yet heard the result of this attempt.

14. I have not entered into the question as to whether the fisheries should be sold yearly as in the last two years, as I have not been asked to do so. I think, however, if the villagers are allowed to take what they want for their own consumption that the fisheries might be put up to auction as heretofore. If not sold, it is certain that they will be poached by Natives of India. There would hardly seem to be any necessity for insisting on a close season as the monsoon itself

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puts an end to all oyster collecting. Possibly the fisheries should only be sold for three years and then allowed to lie fallow for, say two years.

From the Reporter on Economic Products to the Government of India, to the Superintendent, Indian Museum, Calcutta,—No. 684—191, dated Calcutta, the 26th March 1897.

I have the honour to enclose a printed copy of letter No. 358, dated the 1st February 1897, from the Deputy Commissioner, Bassein, together with the specimens referred to therein as A, B, and C, and to request the favour of being furnished with your opinion on the subject as well as the names of the specimens forwarded.

From the Officiating Superintendent of the Indian Museum, to the Reporter on Economic Products to the Government of India,—No. 100, dated Calcutta, the 29th March 1897.

In reply to your letter No. 648—191, dated the 26th current, I have the honour to inform you that the shells referred to therein are **Placuna placenta**.

From the Reporter on Economic Products to the Government of India, to the Revenue Secretary to the Chief Commissioner, Burma, Rangoon,—No. 954—191, dated Calcutta, the 4th May 1897.

With reference to your letter No. 277-2 F.—9, dated the 10th March 1897, forwarding printed copies of a report by the Deputy Commissioner of Bassein regarding the pearl fisheries of that District, together with the specimens referred to therein, I beg to state that the specimens marked C were submitted to several of the principal precious stone dealers here who report as follows:— "The specimens are not pearls, but are formations of a bony nature found inside of oysters which are supposed to be the primitive stage of pearls. As they are, the specimens are of no value." Those marked B are shells of the **Placuna placenta** also.

Register No. 8980.
" 8980a.

Register No. 8982.

2. This additional information, it is contemplated, shall be published as a supplement of *The Agricultural Ledger No. 36 of 1896.*

G. I. C. P. O.—No. 71 R. & A.—9-6-97.—2,200.

P. 355-60.

Agricultural Series, No. 19.)

THE

AGRICULTURAL LEDGER.

1897—No. 2.

EMBANKMENTS IN AGRICULTURE.

(DAMS AND BUNDS.)

[*Dictionary of Economic Products, Vol. III.*, E. 198 a.]

CONSTRUCTION OF DAMS AND BUNDS IN AGRICULTURE:

A Review of the Official Correspondence on the above subject, prefixed by Passages selected from the Proceedings of the Agricultural Conference held at Simla in October 1893.—By THE EDITOR.

The following passages taken from the Proceedings of the Agricultural Conference held in Simla during the 2nd to the 7th of October 1893 may be usefully given as an introduction to the more detailed official correspondence which has been conducted on the subject of Dams and Bunds constructed for the prevention of erosion or for the fertilization of soil by silt deposits :—

"The first subject on the table for discussion was that of the construction of Dams and Bunds for (*a*) the prevention of erosion, and (*b*) the fertilization of land by deposit of silt. Captain Chapman had devoted much attention to this subject, and the matter had been taken up in a Circular No. 23, dated 21st June 1893 (*page 3 below*), in which information was asked for, regarding action taken during recent years and the practices prevailing among agricultural classes.

"The evidence in the replies to the Circular (*pages 4 to 43 below*) indicated that in many provinces the practice of fertilizing agricultural land with silt was not uncommon, especially in Madras, the Central Provinces, Bengal, and parts of the Punjab and Bombay. On the other hand, the fertilizing silt in many rivers was not utilized, notably in the case of rivers issuing from the Himalayas.

"As regards the prevention of erosion by drainage and the reclamation of land at the heads of ravines, evidence was brought forward that in the Shahpur district of the Punjab and on Captain Chapman's Estate in Oudh experiments in this direction had been carried out and had proved remunerative. (*Agricultural Ledger No. 16 of 1894.*)

E. 198 a.

"In the first case worthless land so reclaimed was found to be worth R100 an acre or more; in the second the cost was R100 an acre and the rent of the reclaimed land R10 an acre. In view of the extensive and serious deterioration of agricultural land due in some provinces to drainage erosion, the Conference considered the subject of importance. Captain Chapman suggested that the reclamation of ravine land would be a useful famine work, and Mr. Miller stated that it was included in the list of famine works in the North-Western Provinces. The President also stated that it had been recommended by the Government of India, but that the system could not be adopted in time of famine unless it had been previously worked out in a practical manner by experiment. This conclusion was accepted.

Conf. with Remarks on Ravine Embankments in Banda Districts, pp. 16, 22, 27: Dera Ghazi Khan, p. 29.

"Mr. Ribbentrop drew attention to the necessity for diminishing the damage done by ravines and sandy torrents in the Sub-Himalayan tracts by proper afforestation of the head waters. He subsequently furnished a note on the subject. (See below.)

RESOLVED:

(1) "That the Government of India be invited to circulate separately the papers submitted to the Conference on the subject.

(2) "That the subject be taken under special consideration by the Departments in those Provinces where the local conditions might require it." (*Page 13 of Proceedings of the Agricultural Conference of 1893.*)

Note by MR. B. RIBBENTROP, C.I.E., *Inspector General of Forests to the Government of India, on the reboisement of the heads of destructive ravines.*

1. In the discussions, which followed Captain Chapman's interesting account of the restoration of ravines, the correctness of the principle, that all such improvements must proceed from the head downwards, was unanimously acknowledged. This may be sufficient as regards ravines with a gentle incline and somewhat removed from the hills; but when the periphery of the ravines to be dealt with includes head-waters situated in mountainous or hilly ground, it is necessary that the barrage work should be accompanied and even preceded by an afforestation of the higher portions and the steeper slopes, the denudation of which is the main cause of the existence of ravines and torrents. Without such afforestation the works of reclamation result in a constant and frequently ineffective struggle against nature, a fact which has been fully recognised in France, which, of all European countries has, during the last 30 years, taken the lead in reclamation works of this kind, and which is consequently able to show the best practical results.

2. The magnitude of the works carried out in that country can be gauged by the note appended to the introduction of E. Thierry's "*Restauration des Montagnes, comition des torrents, reboisement*;" when it will be seen that, from 1861 to 1888, 144,000 hectares were treated at a cost of 51,670,000 francs.

3. The French literature on the subject is very complete as regards the subject in question, and I would strongly recommend the study of the book above quoted, and of the work of Alexander Surell, "*Etude sur les torrents.*"

4. The whole of the introduction of Thierry's book should be read, but I would draw special attention to the paragraph on page 9, which runs as follows :—

Voici l'ordre qui généralement a été suivi pour l'exécution des travaux :
1°. Tracé des *perimètres* des terrains à reboiser ou à maintenir boisés ;
2°. Reboisement des parties stables ;
3°. Fixation des terrains instables, en commençant par les ravins et en terminant par la branche principale des torrents ;
4°. Reboisement des terrains instables au fur et à mesure de la fixation des torrents et ravins, sans laquelle l'instabilité des parties voisines était incurable. (*Page 46 of Proceedings of Agricultural Conference of 1893.*)

REVIEW OF CORRESPONDENCE.

The following Review of the correspondence on the subject of Dams and Bunds may be here given. It may perhaps be as well to explain that this does not profess to be a complete statement. All letters that contribute additional information (but in some cases only passages of such letters) have been quoted. The abstract thus presented will, it is believed, convey the chief facts that have been brought to light. The omissions are mainly acknowledgments and covering letters.

From Sir E. C. Buck, Kt., C.S.I., Secretary to the Government of India, to the Secretary to the Governments of Madras, Bombay, Bengal, the North-Western Provinces and Oudh, the Punjab, the Chief Commissioners of the Central Provinces, Burma, and Assam, and the Resident at Hyderabad,—No. 23—113, dated 21st June 1893. **GOVERNMENT OF INDIA.**

I am directed to request that the Director of Land Records and Agriculture may be permitted to collect any information which is available or can be obtained without entailing troublesome enquiry indicating—

(A) the action, if any, which has been taken in recent years in to promote the construction of dams or bunds for other purposes than that of irrigation, *viz.:* (*a*) with the object of preventing erosion by drainage; (*b*) of fertilizing land by deposit of soil; and the success or failure of the works in each case.

(B) the practice, if any, prevailing among the agricultural classes of constructing dams or bunds with the above objects.

2. I am to add that the subject is one which will be brought before the next Agricultural Conference, and to ask that an abstract of any information available or collected may be forwarded to the Government of India by 15th September next.

3. In connection with the above enquiry, attention is drawn to the appended extract from "Irrigation in Southern Europe" (Scott-Moncrieff) which will shortly be under circulation as No. I of the Agricultural Ledger.*

* Issued as No. 1 of 1893.

MADRAS.

I.—MADRAS.

Extract from the Proceedings of the Government of Madras, Revenue Department,—No. 2860, dated 3rd August 1893, on the subject of the Circular letter from the Government of India Revenue and Agricultural Department,—No. 23—113, dated Simla, 21st June 1893.

Resolution.—With reference to the letter from the Government of India read above, the Board begs to report that, so far as it is aware, no action has been taken of late years in this Presidency to promote construction of dams or bunds, either for (1) the purposes of preventing erosion by drainage or for (2) fertilizing land by deposit of soil.

Small Dams to prevent Erosion.

2. Regarding the practice of the ryots in these two respects there is little or no definite information on record. The ryots in all parts of the Presidency are in the habit of making up small dams or banks to prevent erosion of their fields where the fall is considerable. In many places, also, the small bunds round the paddy-fields are made and kept higher than is absolutely necessary to retain a sufficiency of water for the crop in order to secure a deposition of silt from the irrigation water, thus gradually improving the land. All Collectors will, however, be requested to submit, before the 15th August next, any further and more detailed information regarding the practices prevailing in these matters in their districts, and from these reports the Board will prepare an abstract for the information of the Government of India as desired in paragraph 2 of its letter.

Resolution—dated 20th September 1893, No. 380.

A *précis* of the reports received from Collectors regarding the construction of dams or bunds for (1) fertilizing lands by the deposit of silt and (2) for preventing erosion by drainage will be submitted to Government in continuation of Board's Proceedings, dated 28th July 1893, No. 319.

In Coimbatore and Bellary Loans granted for Construction of Bunds.

2. The reports of Collectors give very little information in addition to what is already contained in the Board's Proceedings above quoted. In a few cases in the Coimbatore and Bellary districts loans are stated to have been granted under the Land Improvement Loans Act for the construction of bunds and dams intended to serve the purposes referred to by the Government of India. Beyond this no action has been taken by Government to promote the construction of such works.

3. The agricultural classes are well acquainted with the beneficial results of raising such works both for preventing erosion and catching silt deposits, and they construct these works wherever they are likely to be profitable. It must, however, be remarked that the erection of these works for the express purpose of securing deposits of silt is more or less exceptional and seems to be confined to portions of the districts of Coimbatore, Salem, Kurnool and Cuddapah; but the small bunds, which are everywhere put up round paddy fields for retaining a sufficiency of water for the crop, indirectly secure the above object and prevent the soil and the manure thereon

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from being washed away by drainage water. The bunds are mostly of earth and occasionally of stones or masonry. In the hilly districts, lands on hill slopes are protected from erosion by terracing and cutting side channels for the drainage water.

Precis of reports received from Collectors.

Bunds to prevent Erosion.

Ganjam.—The ryots protect exposed portions of their fields from erosion by building small dams or bunds to divert storm-water and by banking up the sides which are exposed to streams. They do not construct bunds for the express purpose of detaining silt, but the system of rain-fed irrigation common in the district, which consist in terracing lands which have no source of irrigation and would otherwise grow only dry crops, so that each field becomes in effect a small tank for the supply of its own crop and the crops of the lands below it, does very much not only to detain in the paddy fields the silt coming down from dry lands at a higher level, but also to prevent the soil and manure in the fields themselves from being washed away.

Vizagapatam.—The Collector has nothing to add to the information given by the Board in its Proceedings, No. 319, dated 28th July 1893.

Godavari.—The Collector has no information in his office as to the practice prevailing among agricultural classes in the matter of the construction of dams and bunds for purposes other than irrigation.

Kistna.—Report not received though telegraphed for.

Kurnool.—The ryots erect small bunds round their paddy fields to retain sufficient water for their crops and to secure a deposition of silt. Owing, however, to sparseness of population and want of capital this is not done extensively.

Bunds constructed.

Bellary.—In black cotton soils where nallas or water-courses are formed the soil is liable to be washed away from the surface, and it is usual for the ryots to construct, not only mud dams, but also bunds and walls of masonry and stone to prevent erosion by drainage and to promote deposit of silt. During the last famine, large advances were given under the Land Improvement Loans Act in the western taluks of the district for the construction of such dams, and these works wherever constructed have been found of great use to the ryots. The lands on the banks of the Hagari and Tungabadra are protected by rough fencing for growing melons. The silt washed up which is apparently detained by the fencing forms a valuable accretion to the land but such fencing has had to be put a stop to by the levy of prohibitory assessment as diverting the course of the stream to the injury of other riparian proprietors.

Anantapur.—Ryots who own lands in the bed of ruined tanks or by the side of streams or whose lands are traversed by water-courses are in the habit of constructing small bunds, aprons or walls of stone to prevent their lands being damaged. Practice of intentional arrest of water for the purpose of fertilizing land by deposit of silt is very rare, if not unknown.

Bunds to cause Silt Deposits.

Cuddapah.—Earthen bunds are thrown up round wet lands, and where the lands, dry as well as wet, are liable to be flooded dams of loose stones piled up are made round the fields. These dams and bunds are put up to prevent surface soil from being washed away and to promote the deposit of silt; in some places these dams are permanent structures rivetted with stone.

Nellore.—The construction of dams or bunds for purposes other than irrigation is rare, and where it exists it is restricted to the cases already cited in the Board's Proceedings above quoted.

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Chingleput.—Construction of dams for the purpose of fertilizing lands by the deposit of silt is stated to be not practised in the district, though in a few cases bunds are raised to prevent erosion by drainage and the washing away of manure, etc.

Madras.—Small bunds are formed round paddy fields to secure sufficiency of water and prevent manure being washed away.

South Arcot.—Ryots dam up small water-courses in order to fertilize their beds, leading away the drainage in small deep side channels.

North Arcot.—The Collector has nothing to add to the information already given in the Board's Proceedings above quoted.

Salem.—Stone bunds or mud banks with stone revetment are put up round fields for the purposes mentioned in the Board's Proceedings above quoted. Where river irrigation is extensive ridges are made round lands planted with cocoanut, areca and plantain to retain water and secure a deposit of silt. There are also cases of construction of groynes or plantation of *nanal* by riparian proprietors and of ridges or stone walls in dry lands in places where the ground slopes. The only action taken in the district to promote the construction of such dams is the grant of loans in some cases under the Land Improvement Loans Act.

Erosion prevented.

Coimbatore.—The practice of constructing dams and bunds for the purposes mentioned prevails in wet villages and in villages where there are jungle streams which carry off the surface drainage. Dams for the purpose of preventing erosion are of masonry work where the fall of water is considerable, and in other cases partly of earth and partly of masonry. Embankments raised with the object of arresting the silt and fertilizing the land are generally of mud work, an outlet in the form of a *calingulah* being provided for the flow of the surplus water. These earth embankments also improve the water-supply of wells in the vicinity. State loans have been granted in some cases for the construction of such dams.

Trichinopoly.—Banks are commonly constructed in the district by ryots to prevent erosion, but the Collector is not aware that bunds are raised for the retention of silt as distinguished from the retention of water.

Bunds constructed.

Tanjore.—The Collector refers to the bunds put up in Tanjore round wet lands for the purpose of retaining a sufficient quantity of water for the crop and for securing a deposition of silt from the irrigation water. Beyond this he is not able to say anything as to the practices of the district, being new to it ; he, however, observes that in the Coimbatore and South Canara districts, in both of which he has served, stone revetted embankments to prevent erosion of fields by jungle streams are very common, and that such dams are also raised for the regulation of the drainage of black cotton soil fields and for arresting deposits of silt. It is stated further that loans have been given under the Land Improvement Loans Act for the construction of such dams in the Coimbatore district.

Madura.—The Collector has nothing to add to what is stated in the Board's Proceedings above quoted.

Silt Deposits secured.

Tinnevelly.—Ryots are careful to defend their fields from erosion by the erection of banks and where necessary of masonry walls. They store more water in their fields than is necessary for irrigation, and their object in doing so is to secure the benefit of the silt. Silt is also removed to fields from tank-beds when these are dry, and the numerous tanks with their bunds thus serve the purpose of embankments for the object the Government of India has in view, and no special action in this direction seems to be required.

MADRAS.

Nilgiris.—The practice of constructing dams or bunds for the purposes referred to does not prevail in the district and no help from Government has been sought by ryots for such purposes. On hill slopes erosion is prevented by terracing and trenching and in swamps by deep trenches which carry off the large flow of water during the monsoons.

Erosion prevented.

Malabar.—Owners of cocoanut gardens on the banks of rivers are in the habit of putting up small groynes and in some cases temporary palisades of bamboos or cocoanut leaves for preventing erosion by floods. The sides of hills are cut into terraces to prevent crops and soil being washed away during the rains. Small dams or bunds are frequently erected in rivers and estuaries for the purpose of reclaiming land by the deposit of silt. The Collector is not aware of any recent works (he apparently refers to Government works) for the purpose of preventing erosion by drainage or for fertilizing land by the deposit of silt. He refers to the Enamakkal dam in the Ponnani taluk constructed in 1802, which although mainly intended to prevent the inundation of paddy lands by salt water has, he states, the effect of reclaiming land gradually by the deposit of silt.

Hill Sides terraced.

Land reclaimed in River Basins.

South Canara.—The Collector states that the practice prevailing among the ryots is the same as that described by the Board, but adds that it is very common owing to the undulating nature of the country and the heaviness of the rainfall.

Extract from the Proceedings of the Board of Revenue, No. 5700 Mis., dated 5th October 1893; forwards the following letter from the Collector of ***Kistna,***—*No. 3336—218 Dis., dated 20th September 1893.*

In reply to paragraph 2 of Board's Proceedings No. 319, dated 28th July 1893, I have the honour to report that the surmises of the Board with regard to the practice prevailing among the agricultural classes of constructing dams or bunds with the object of preventing erosion by drainage and of fertilising land by the deposit of silt, are correct and of universal applicability in this district.

Grass used to strengthen Bunds.

2. Where fields are situated on a hill side or any declivity, a bund of mud or grass or stone is constructed along the lower margin thereof to prevent erosion. Almost the same practice is obtained with regard to fields on the banks of streams; the bunds in this case are, however, strengthened by the growth of *nanal* grass by the side.

Reclamation by Silt Deposits.

3. The practice of depositing silt for the purpose of fertilizing the land is very generally resorted to in reclaiming large blocks of marshy and saline soils fit for cultivation. The blocks are sub-divided into fields of 2 or 3 acres each, and bunds are raised all round; the Kistna water, through anicut canals, is then allowed to stand in them for a year or two, with the result that the salinity disappears and a good alluvial deposit is left on the surface. The same course is followed to counteract exhaustion of soil. The Delta Water-rate Rule VIII provides free supply of anicut water for this purpose; and the concession is largely availed of in reducing extensive swamps into rich paddy-fields.

BOMBAY.

II.—BOMBAY.

From G. W. VIDAL, Esq., I.C.S., *Acting Chief Secretary to the Government of Bombay, to the Secretary to the Government of India, Revenue and Agricultural Department,—No. 6904, dated Bombay Castle, the 25th September 1893.*

Forwards copy of a memorandum received from the Survey Commissioner and Director of Land Records and Agriculture, furnishing the requisite information.

Memorandum by E. C. Ozanne, Esq., I.C.S., Survey Commissioner and Director of Land Records and Agriculture.

Bunds frequent.

The practice of constructing embankments or bunds for purposes other than irrigation has long prevailed among the agricultural classes both in the hilly tracts and in the open plains of the Deccan, Karnatak and Konkan. The plains of Guzerat are too flat to make such dams useful. Sind * is not dependent on rainfall. In Khandesh, the practice is not general for reasons not fully apparent.

hree Classes.

2. Field embankments may be divided into three classes, *viz.*, (1) those essential to the particular method of cultivation; (2) those to correct slopes of fields in undulating lands with a view to prevent erosion by surface drainage, etc., and (3) those raised to reclaim lands from the sea or tidal rivers. The construction of the last class of embankments generally demands large capital, both on account of the extent and costliness of embankment necessary and because return for capital expenditure is not immediate or early.

3. In the dry crop lands of the Deccan and the Karnatak embankments in fields are mostly constructed with the direct object of preventing erosion by surface drainage in sloping lands, but by intercepting flood water, they also catch silt which increases the fertility of the land and store a supply of moisture very important where the rainfall is untrustworthy. In the sweet rice lands of the Konkan and the hilly tracts of the Western Ghats, embankments are universal for impounding water at certain times and for certain periods, in accordance with the requirements of rain rice cultivation. No doubt, incidentally, lands situated in the vicinity of hills are largely benefited by deposits of silt which is indeed the only manure which rice land receives outside the seed beds. Embankments are made in the South Konkan to increase the area and depth of soil in the hollows of the large stretches of sheet rock by silt deposit.

Salt Land Reclamations.

Salt land reclamations date far back. The whole Konkan coast is studded with such reclamations. Salt marsh is converted into rice land by excluding the tide and by gradually sweetening the soil by the passage of rain floods in the monsoon. Rice straw, grass and branch loppings are used to strengthen the mud embankments which are occasionally faced with stone: and the growth of mangrove and other shrubs that flourish in salt water is encouraged.

* The assumption that the practice does not obtain in Sind is incorrect. It prevails largely in tracts beyond the reach of irrigation from the river and nearer the hills, sloping fields being bunded at the lower end to retain the rainfall.

BOMBAY.

4. The ordinary field embankments as well as the more pretentious works of salt lands reclamation dams are generally constructed with success. As illustrating the success attained by ordinary ryots in the construction of field embankments in the dry crop lands of the South Deccan and the Karnatak, the following passage is quoted from the Collector of Bijapur's Administration Report for 1891-92:—"The other permanent improvements mainly carried out were field embankments which were made in all directions. Almost the only good crops reaped being those enclosed by the present embankments naturally demonstrated the advantages of embanking their fields. As regards salt land reclamations, the Collector of Thana writes:—"this system, as practised in Thana, is best described in the Thana Gazetteer, pages 282 and 283. Very considerable reclamations have been made since the article was written twelve years ago, and no encouragement is needed. The process is extremely lucrative; and the competition of capital for investment in it is always brisk."

Field Embankments.

5. No recent Government action appears to have been directed specially to the encouragement of field embankments, but the District Officers urge that the *Takavi* advances under the recent liberal rules have been in reality largely applied for and utilized in carrying out this form of agricultural improvement. This belief is supported by the figures shown below, which represent the sums granted for construction and repairs of field embankments in 1892-93 in the several districts of the Deccan and the Karnatak. The details are:—

Takavi Advances applied to Embankments.

Conf., pp. 14 and 16.

Districts.	Amount.	Remarks.
	No.	
Khandesh . .	...	Not customary to raise field bunds.
Nasik . . .	4,025	Practice not general.
Ahmadnagar . .	725	Government aid only sought in ghát taluka of Akola.
Poona . . .	18,710	
Sholapur . .	25,110	Probably not solely for field embankment.
Satara . . .	3,375	For six talukas only.
Belgaum . .	25,390	
Bijapur . .	4,605	
Dharwar . .	10,800	Information available for 3 talukas only.

As regards salt land reclamations, the concessions given in rule 21 of the rules framed under section 214 of the Bombay Land Revenue Code are considered sufficiently encouraging.

Rules for Salt Land Reclamation.

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III.—BENGAL.

From T. W. RICHARDSON, ESQ., I.C.S., *Under Secretary to the Government of Bengal, to the Secretary to the Government of India, Revenue and Agricultural Department,—No. 1097 T. R., dated Darjeeling, the 18th September 1893.*

Forwards a copy of a note prepared by Mr. Bhupal Chandra Basu, an Assistant in the Department of Land Records and Agriculture, showing the use made of dams and embankments in Bengal for purposes other than that of irrigation.

Memorandum by Mr. Bhupal Chandra Basu.

The Government of India have enquired whether any action has been taken in recent years in Bengal (presumably by Government) to promote the construction of dams or bunds for purposes other than that of irrigation, *viz.*—

(*a*) to prevent erosion by drainage; and
(*b*) to fertilize land by deposit of silt;

and also how far it is a practice among the cultivators to construct dams or bunds with the above objects.

A.—To prevent Erosion by Drainage.

Embankments across Depressions and across Streams.

This appears to be the kind of work referred to by Dr. Voelcker in his Report on the Improvement of Indian Agriculture (page 53). It consists in throwing up embankments (dams) across hill-streams or ravines, with a view to impede the rush of rain-water and to encourage the formation of soil in the beds of the reservoirs which form behind the dams. It is believed that the main object of such works is the collection of a store of water for the cultivation of rice in fields which are prepared at lower elevations. Waste lands, subject on account of their slope to erosion by surface drainage, can be converted by terracing and with the help of reservoirs of water formed by dams, into valuable rice-fields. Throughout Chota Nagpur and the western parts of the Burdwan Division, it is a common practice to construct embankments across the face of natural depressions between contiguous ridges of uplands or across streams, with a view to hold up the water for irrigation. The sloping lands lying below the embankments are then levelled and enclosed with low ridges, and in this way bare wastes, which in their natural state support little or no vegetation, being covered with a thin coating of soil which cannot accumulate owing to constant wear by drainage, have been turned into fruitful rice-fields. In a report on the agriculture of the Lohardaga district, by Mr. Bhupal Chandra Basu, special stress has been laid on the importance of constructing embankments and the preparation of rice-lands by terracing (*vide* pages 47, 126 and 127). There is an indefinite scope for work of this kind and

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Mr. Basu is of opinion that there is no other work in which moderate amounts of capital can be so profitably invested as in these.

Prevention of Erosion.

There is another class of embankments also called *bunds*,* which are made to prevent erosion by drainage. These are low ridges made along the boundaries of fields with a view to prevent the fine top soil (as well as manure) from being washed off by heavy rain, and also to have the soil well soaked with rain-water. They are chiefly found in South Bihar. An interesting account of them will be found in Mr. Grierson's *Notes on the Gaya district* (page 53). The practice of enclosing fields with ridges is confined to stiff clay soils found on the uplands, which being of an extremely close texture are too slow to absorb rain-water, which, if the field were not enclosed, would quickly flow off, leaving them quite high and dry. The raiyats of South Bihar attach much importance to the retention of water in fields towards the close of the rainy season for the purposes of *rabi* cultivation. It is believed that similar practices are followed in Bundelkhund and parts of the Central Provinces (*vide* page 79 of Dr. Voelcker's Report). The extension of the practice is being strongly advocated in the Central Provinces, as *rabi* land enclosed with ridges and well soaked with water are found to suffer comparatively little from drought.

* These are very different from dams.

Much importance is also attached everywhere in Bengal to the enclosing of fields (specially of fields which have been heavily manured) in order to prevent the fine top-soil and manure from being washed away; but in this as well as in many other respects, the practice of the cultivators falls far short of their precepts.

B.—To fertilize Land by deposit of Silt.

Deposits of Silt from Sone Canals.

In Mr. Basu's *Notes on Indian Agriculture* (pages 43-44), several instances are recorded of cultivators enriching their fields by deposit of silt. The process is known in England as *working*, and is largely followed in the Fens of Cambridgeshire. In the south of France large areas of barren, stony land are being reclaimed by inundating them with the thick turbid water from irrigation canals. The practice is described in a report written by Mr. Basu in 1885, and published by order of the Secretary of State. Very probably Colonel Scott-Moncrieff refers to this very practice (known as *colmatage*) in his book, to which the Government of India have drawn attention. An exact analogy of the process was found by Mr. Basu in *pargana* Tamar in the Lohardaga district.

The Sone canals were constructed solely for the purposes of irrigation and navigation, but they have also served another useful purpose, namely, the enriching of sandy soils with silt. In the south of the Shahabad and Gaya districts, where the soils are of a poor, sandy description, the canals have done much good by the deposition of silt.

An indirect result of the system of *ahara* irrigation obtaining in South Bihar and Palamau is the fertilizing of the lands situated in

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the basin of the reservoirs known (as *doole* lands) with silt. These lands are highly valued for the cultivation of wheat and other *rabi* crops.

Office memo. from C. W. ODLING, *Esq., Secretary to the Government of Bengal, Irrigation Department, to the Government of Bengal, Revenue Department,—No. 141, dated the 19th September 1893.*

Calcutta Bricks made of Silt Deposits.

In reply to Revenue Department Office Memorandum No. 1098-T.R. of the 18th instant, the undersigned has the honour to say that no works have been undertaken with the objects mentioned under the head A. With regard to B, what is known as *warping* is practised on the banks of the Hooghly river below Calcutta. Shallow tanks are formed below high water level and water is admitted at high tide and allowed to escape at low tide after the greater part of the silt held in suspension has been deposited. But the object is usually rather to procure earth for brick manufacture than for agricultural purposes. No other instances of endeavouring by artificial means to procure a deposit of silt for agricultural or other purposes are known to this Department. This year it has been noticed that the irrigation of rice crops is extensively carried on from the Sone canals during the heaviest rainfall, the cultivators giving as their reason that there is silt in the canal water, and that, as they pay for the water, they might as well have it, though beneficial only so far as a deposit of silt is obtained.

Silt from Sone Canal Water.

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IV.—NORTH-WEST PROVINCES AND OUDH.

From the Chief Secretary to Government, North-Western Provinces and Oudh, to the Secretary to the Government of India, Revenue and Agricultural Department,—No. 2671, dated 16th September 1893.

Submits copy of a letter No. $\frac{\text{T.-325}}{\text{V.-46}}$, dated 14th September 1893, together with enclosures in original, from the Director of Land Records and Agriculture of these Provinces, containing information as to the action taken to promote the construction of dams or bunds for other purposes than that of irrigation.

Revenue Department.

Letter No. $\frac{T\text{-}325}{V.\text{-}46}$, dated 14th September 1893, from the Director of Land Records and Agriculture, North-Western Provinces and Oudh.

I have the honour to acknowledge receipt of your letter No. $\frac{1919}{\text{I-153-B.}}$, dated 4th July 1893, forwarding the Government of

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India's Circular No. $\frac{23}{113}$, dated 21st June 1893, regarding the construction of dams or bunds for other purposes than that of irrigation. The time allowed for a reply has been too short to admit of any detailed enquiry; but I forward such information as I have been able to collect as to the action taken by Government or its officials to promote such works, and the prevalence amongst agriculturists of the practice of constructing them.

See The Agricultural Ledger No. 16 of 1894.

2. The improvements carried out by Captain Chapman at BETI in the Partabgarh District are believed to have been undertaken with the aid of an advance from the Government. There is no information of recent date in my office about them; but as the Agricultural Chemist to the Government of India has visited Beti, he will be able to lay before the Agricultural Conference any information regarding them that may be wanted.

See letter, p. 25 below.

3. Some years ago extensive works for the prevention of erosion of the land near Jhansi were undertaken at the instance of Mr. Ward, the Commissioner. The Government gave the services of its Engineers for their construction, and made a grant of R8,000 in 1887, which was supplemented by a grant of R2,000 in the following year from the Government of India. Further grants of R4,363 in the close of that year and of R1,000 in 1889 were made, and a considerable number of embankments were constructed, the management of which was, in 1890, made over to the Irrigation Department. The Collector of Jhansi has not yet answered the reference made to him about the construction of embankments in his district, and recent reports of this Department contain no information about the Jhansi experiments; but there is probably not much to be added to the account given at page 53 of Dr. Voelcker's report. If any information of importance is added by the Collector, it will be forwarded when received.

Reclamation of Ravine Land.

4. An interesting and successful experiment in the reclamation of ravine land, partly by means of embankment, is to be found in parts of Grass Farm and Macpherson Park at Allahabad, but there is no detailed information on the subject in my office, nor has the Collector noticed these experiments in his report, extracts from which are appended to this letter.

Silt Deposits from Canal Water.

5. The embankments made on the usar reserves at Cherat and Amramou do not appear to fall clearly under either of the heads into which the Government of India have divided embankments for purposes other than irrigation. They may, however, be mentioned, as the deposits of silt by canal water, though this was not the object aimed at, has probably assisted the reclamation of some of the usar lands. At Cherat plots were marked out and embanked by walls from 3 to 4 feet high, and rain water allowed to accumulate on them. They were then deeply ploughed and heavily manured, with the result that an area of 76 acres was sufficiently reclaimed to allow of the growing of fair kharif and rabi crops. On some of the lower fields, I noticed at my last visit to Cherat a thick deposit of silt, presumably left by the canal water used to irrigate the crops. In several of the

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experimental usar plots under the management of the Irrigation Department, the experiment took the form of running canal water over the land to leave a layer of silt. The Sakram plot of 40 acres, for example, near Etawah, was treated in this way. In 1874, canal water was run over it for four months and a layer of silt of from three to four inches in depth was deposited on it. Afterwards the flooding was repeated, and the silt was subsequently spread over the adjoining usar to some distance. In 1883, it was reported that 33 acres had been reclaimed and the plot was let for R96. The accounts of that time showed a profit of R825, the value of canal water supplied being omitted from the calculation of expenditure. Similar experiments were tried at Khandari and Turaia in the same district; but though the land was covered with silt, it was impossible to get let out at remunerative rates to tenants. These experiments have now been discontinued.

Reclamation of Usar Lands by Silt Deposits.

***Takavi* Advances for Embankments.**

6. In some of the Bundelkhand Districts the Government has promoted the construction of embankments by grants of *takavi*. In Hamirpur, during the last five years, R11,500 have been advanced to 155 persons in 89 villages for this purpose, and it is reported that the embankments have usually been successful. The statistics for the Banda District are incomplete; but in six out of the eight Tahsils of that district, nearly 20,000 have been advanced for embankments during the last two years. The Collector in a letter,* a copy of which is attached, states that these embankments are meant not to prevent erosion from drainage, but to fertilise land by deposit of soil. It is more probable, in my opinion, that the two purposes cannot in all cases be distinguished, and that many of the embankments are meant, in the first instance, to prevent ravines from being eaten away and then to lead to the deposit of a layer of good soil. In no other Bundelkhand District is it said that the embankments are not meant to prevent erosion.

* No. 2058, dated 11th August 1893, with statement, *page 16 below*.

7. The construction of bunds has not unfrequently been undertaken in Court of Wards estates. In Bara Banki a large number have been made, some to prevent erosion or to reclaim lands already cut away by drainage; others to fertilise land by deposit of soil. It is said that in one estate a considerable area of land once cut up by ravines and drains has been reclaimed; but no definite details of the area affected or the profit and loss on the experiment have been given. In Kheri, in two estates, embankments have recently been constructed; but it is too soon as yet to pronounce as to the result. Further information regarding the action taken by Court of Wards will be found in the correspondence noted in the margin, of which a copy is attached.

Paragraphs 2 and 3 of letter No. 1592, dated 20th July, from the Collector of Jalaun; *see. p. 17*.

Letter No. $\frac{1815}{\text{VII-69}}$, dated 29th August, from Deputy Commissioner of Sitapur; *see p. 17*.

Silting accomplished by Canal Department.

8. The Canal Department frequently undertakes operations for silting land near its banks, or constructs embankments for purposes other than irrigation, such as to prevent floods. I am not sure that these operations fall within the scope of the Government of India's

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Circular; but enclose a copy of a letter (No. 2365, dated 17th August) from the Superintending Engineer of the Second Circle, which will explain the nature of the works referred to. *See p. 18.*

Encouragement of Silt Deposits unknown in the Himalayan Tracts.

9. In regard to the practices of agriculturists, the replies of District Officers vary, partly because some of them have dealt with the construction of *bunds* for any purpose other than irrigation, while others have confined themselves to the two special purposes mentioned in the Government of India's Circular. The extract from "Irrigation in Southern Europe" was not circulated in time for District Officers to consult it; but no measures similar to those mentioned by Colonel Scott-Moncrieff are reported from any quarter. In the Himalayan and sub-Himalayan districts, where, if any where, such measures might be possible, embankments appear to be almost unknown, except for irrigation or for the prevention of damage by flood. The District Officers of Bijnor, Moradabad, Bareilly, Shahjahanpur, Pilibhit, Almora, Garhwal, Naini Tal, Kheri, Gonda, Bahraich, Basti and Gorakhpur report that the practice of constructing *bunds* with the objects mentioned in the Circular does not exist in their districts. The Superintendent of the Dun reports that some of the leading zamindars do construct such *bunds*, and an extract from his letter * on the subject is enclosed.

* No. $\frac{1196}{\text{VII}}$, dated 5th August 1893; *see p. 18.*

10. From the central districts in the Provinces the replies are generally in the negative. The Collector of Meerut states that—"Ridges or banks are sometimes thrown across natural drainage lines and the beds of the valleys cultivated with sugarcane, etc., thus in a few years silting up the natural shallow valleys and causing floods; and from Sultanpur it is reported that a few bunds have been erected to prevent erosion from drainage by large proprietors, and that similar action is frequently taken on a small scale by individual cultivators to prevent the cutting away of their fields. The Deputy Commissioner of Rai Bareli has explained in detail the purposes other than irrigation for which bunds are constructed in his district, and a copy of his letter † is attached, as his account is probably applicable to many districts besides his own.

† No. $\frac{1467}{\text{VII}}$, dated 4th August 1893; *see p. 19.*

Jumna Embankments.

11. It is in the southern districts lying on or south of the Jumna that embankments are most frequently constructed by agriculturists. Some are made simply to keep out floods, as in the cases reported by the Collector of Muttra; others to prevent erosion; others to secure a deposit of silt. In Hamirpur, it is said that *bunds* are often made for the purpose of eradicating *kans*. Information as to the practices of the southern districts in these matters will be found in the following enclosures to this letter:—

Copy of a letter No. 1462, dated 3rd August 1893, from Collector of Muttra; *see p. 19.*

Extract (paragraphs 3, 4 and 9) from letter No. 3679, dated 15th August 1893, from the Collector of Allahabad; *see p. 20.*

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Extract (paragraph 43) of Assessment Report on pargana Banda; *see p. 21.*

Extract (paragraph 55) from the Settlement Report on the Banda District; *see p. 22.*

Copy of a note on the construction of bunds in Rewah and Bundelkhand, drawn up by the Assistant Director from information supplied by one of the masters of the Agricultural School; *see p. 22.*

Conf. with p. 14.

From the Collector of **Banda**, *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh,—No. 2058, dated 11th August 1893.*

Takavi Advances; Fertilization by Deposits.

In reply to your No. 2761-V-46 of the 12th ultimo, giving cover to Government of India Circular No. 23-113 of the 21st June 1893, I have the honour to state, with regard to (*a*) that dams or bunds are not constructed in this district with the object of preventing erosion by drainage. With regard to (*b*), a considerable number of bunds have been constructed within recent years with the object of fertilizing land by deposit of soil. They are popular and efficacious, and *Takavi* is given freely for the purpose. The following statement gives the number of bunds constructed from *Takavi* for the purpose within the last two years and the area benefited thereby: (1) in Parna and Rakar; (2) in Mar and Kabar. The statistics have been obtained from Tahsils, and I have discussed them with all the Tahsildars at a recent Committee. I was obliged to omit the statistics for two Tahsils, Baberu and Badausa, as I found them to contain a number of bunds round rice-fields, which of course should be considered as "bunds for irrigation purposes." It is possible the figures for the remaining Tahsils contain a few of such bunds, as the Tahsildars did not apparently fully understand the distinction; but most, if not quite all, are for fertilization by deposit of soil. That is the object with which most bunds, putting aside bunds round rice-fields, are constructed in this district. I could have given more accurate details after correcting the Tahsildar's error; but note that you require reply not later than 15th August, which leaves no time for further enquiry.

Memorandum of bunds or dams constructed during the past two years, ending 1892-93, in the Banda District.

Area so improved.

Name of Tahsil.	Parna-Rakar.			Mar-Kabar.		
	No. of bunds or dams constructed.	Area benefited.	Cost.	No. of bunds or dams constructed.	Area in which constructed.	Cost.
		Bighas.	R		Bighas.	R
Banda . .	35	1,821	3,638	44	1,721	4,651
Pailani . .	3	88	150	19	1,349	1,148
Kamasin . .	6	123	770	...	...	...
Mau . .	28	765	2,555	13	128	539
Karwi . .	11	480	3,580	23	284	529
Girwan . .	6	267	708	3	69	232
Total .	89	3,544	11,401	102	3,551	7,099

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Extract paragraphs 2 and 3 from letter No. 1592, dated 20th July 1893, from the Collector of **Jalaun**, *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh.*

Conf. with p. 14.

2. A few works of this sort have been undertaken in Court of Wards estates, where the slope of the country was not too great. These have been attended with considerable success, whole fields of good black cotton soil being saved in this way as in the Dhagwan Khurd estate. These bunds were in fact merely ridges made across the bottom of a sloping field, and were meant to prevent *nalas* from forming.

3. Attempts to dam up water in *nalas* and so get a deposit of good soil, as well as prevent erosion, have also been tried, and a certain amount of success obtained in the Beona estate. Undersigned, however, is not very confident as to their permanent utility, as the water cuts round or under the bunds, the slope being so great. Also these works cost a good bit of money.

From the Deputy Commissioner of **Sitapur**, *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh,—No. 1815—VII-69, dated 29th August 1893.*

Conf. with p. 14.

With reference to your No. 2161—V-46 of 12th ultimo, I have the honour to submit the information which the Tahsildars have furnished on the subject. I have called for further particulars, but do not expect they will be of much value. The question raised is, however, of considerable importance, and I think you will not object to my going outside my district to furnish some instances, the existence of which, owing to the changes of officers and subordinate officials, have possibly been overlooked.

Bunds to cause Silt Deposits.

In 1876 or 1877 the late Mr. Carnegy, who was formerly Commissioner of Rai Bareli, recommended my trying the effect of a small over-fall to prevent erosion, which was occurring on some of the nazul lands. He stated he had tried it on, I think, an artillery parade ground at Allahabad years ago, and with excellent results. It certainly was efficacious in the instance I refer to. But this was on a small scale. On going to Partabgarh I found Captain Chapman had been carrying on extensive experiments in the same line. He had, however, used masonry dams, as there were a large number of Court of Wards villages at Partabgarh. I erected several of these dams, some near the Sai Naddi in the Kythola estate and at Bela Partabgarh, in one instance repairing a very large embankment, which had been cut through prior to the mutiny at Sultanpur, on the Karwar estate at Mahmoodpur and at Bhandasa; also at a deep *nala* 3 miles from Sultanpur, and at other places in this district. Several large dams of puddled clay only were made with the view of staying erosion or denudation, and I was informed the results were good beyond expectations.

At Bara Banki a few such dams were tried, but not on the same extensive scale. It would be interesting to know whether these works are still in existence, as they were *kaçha*. They would, unless properly supervised, in all probability, disappear in the course of a few years. I am, however, convinced of this great utility, and with the construction of proper masonry escapes they should last for years. But funds were not always available for these latter. That on the nala * near Sultanpur was provided with an escape : it was over 100 feet long and 27 feet or more

* Jamnawaris.

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high, and the District Engineer informed me some time ago that it had stood the test of several heavy rains.

From the Superintending Engineer, 2nd Circle, **Agra**, *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh,—No. 2365, dated 17th August 1893.*

Conf. with p. 15.

Training Embankments on Rivers.

In reply to your No. $\frac{2397}{V-46}$, dated 2nd August 1893, I beg to say that the bunds you refer to were constructed as training works for the purpose of leading the river Ganges in a normal direction to the Narara weir and to keep it from eroding the canal channel. Agricultural improvement was not much considered, although incidentally such improvement has been effected by confining the deeper river channel within certain limits and by the prevention of erosion by floods over culturable land.

The site of training works extends from the railway bridge at Rajghat (Oudh and Rohilkhand Railway) for a distance of 23 miles down the Ganges to, and some distance beyond, Sankara in the Aligarh District.

From Rajghat to Narara the training works are on both banks of the Ganges from Narara down stream on the right, or canal side, only. The groynes are parallel embankments running out over khadir land from the high ground, are about normal to course of the river, and about half a mile apart. The groyne extends out into the khadir to the limit at which it is desirable that the river channel shall be retained, and ends in a nose which is securely pitched with heavy block kankar. Across spur projects up stream at right angles to the main spur at a distance of about 100 feet short of the end of main spur, and this, like the main nose of groyne, is securely pitched.

These works were started about 1886 and are still incomplete; but so far they have been successful as regards the ends in view.

From the point of view of the agriculturist, I should doubt if training works like these would pay, except perhaps close to large cities where land was very valuable. It is not alone the first cost, but the maintenance that runs high; and it may take many years before the land between the groynes is silted up sufficiently to allow of cultivation or even grazing.

Conf. with p. 15.

Extract from a letter from the Superintendent, **Dehra Dun**, *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh, —No. $\frac{1196}{VII-97}$, dated 5th August 1893.*

Bunds to prevent Erosion.

2 A (*a*). The practice of constructing dams or bunds for the purposes of preventing erosion by drainage has been in vogue for some years past among some of the leading zamindars, such as Mr. Mackinnon and Chaudhuri Shib Ram. These bunds are built of wooden frames enclosing boulders and are known as *khatahs*. They last about two years, and have been found effective for the purpose for which they were designed.

(*b*). These bunds have never been erected in this district for the purpose of fertilizing land by deposit of soil. Dr. Leather, Agricultural Chemist to the Government of India, is at present engaged in experiments with bunds of this nature; but it will be impossible to pronounce on the success or failure of his attempts before the cold weather.

2 B. No such bunds appear to have been constructed by the agricultural classes generally. Only a few of the more enlightened zamindars have ever taken up the subject.

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From the Deputy Commissioner of **Rae Bareli,** *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh,—No.* $\frac{1467}{VII}$, *dated 4th August 1893.*

In reply to your No. $\frac{2161}{V-46}$, dated 12th July 1893, I have the honour to state that the construction of bunds for other purposes than that of irrigation is common in the district.

Conf. with p. 15.

Jhata Bunds.

1. Perhaps the most usual form which bunds not intended to procure a supply of water take is that of the *Jháta* frequently made in the shallower parts of *táls* to prevent transplanted rice from being flooded. These *Jhátas* are usually made by damming the flow of water through a *tál* into a central space, so that in floods the shallower outer parts of the *tál* in which rice is grown are not affected. They are rarely more than 6 or 7 feet in height. An enclosure raised on all four sides is not infrequent if the land round the *tál* is not high enough to be beyond danger of being flooded. Dams are similarly but less frequently made for the protection of spring crops. These are sometimes on a very extensive scale where the flow of water from a large usar plain is likely to lodge on and damaged cropped land.

Prevention of Erosion.

2. Dams to prevent erosion are also common. Their use is well understood; but their number on a large scale is limited by the fact that erosion in general occurs only in sandy soils, dams constructed in which are very temporary.

Silt Deposits.

3. Dams constructed solely to fertilize land by deposit of soil are also met with. Irrigation dams have the same effect, and old dams are therefore often the occasion of constant quarrels between people who wish to occupy the new land deposited, and therefore to diminish the supply of water retained by the dam and those whose rights of irrigation are thereby interfered with.

4. Dams for use as roadways are very frequent. They are cut through in the rains, and the gaps repaired on the flow of water ceasing.

From the Collector of **Muttra,** *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh,—No. 1462, dated 3rd August 1893.*

Conf. with p. 15.

In answer to your No. $\frac{2161}{V-46}$, dated 12th July 1893, I have the honour to say that no recent action has been taken to promote the construction of protective dams or silt traps in this district.

Bunds against overflow of Jumna.

2. There was formerly a dam at Musmina, Tahsil Mat, and there is still a dam at Kaela, Tahsil Muttra, to keep the flood water of the Jumna out of cultivated depressions which were once beds of the river. If the river enters these depressions, its water remains in them until the period of the spring sowings is past.

3. The Musmina embankment disappeared many years ago. The Kaela embankment has in recent years been breached and mended thrice by the landholders at a reported cost of R500 the first, R200 the second and R150 the third time. Advances under the Land Improvement Act would have been granted if required, but were not asked for. The dam has again been breached this year, and will doubtless be repaired during the winter. The area of spring crops whose sowing it has rendered possible has during the past three years averaged over 51 acres yearly.

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Extract, paragraphs 3, 4 and 9, from a letter No. 3679, dated 15th August 1893, from Collector of **Allahabad,** *to the Director of Land Records and Agriculture, North-Western Provinces and Oudh.*

3. The Tahsildar of Bara reports that numerous bunds have been constructed by the zamindars and the cultivators during the last six years with the object of preventing erosion by drainage and of fertilizing the land by the deposit of soil. Earth has also been added to many of the old bunds. These works have been successful in each case. The cultivators also construct dams around their rice-fields to prevent the water from running off and to improve the production of rice, and in places which are inundated, they construct bunds with the aid of the zamindars to check the outflow of the water.

4. The Tahsildar of Meja reports that in order to prevent erosion by drainage, the zamindars and the cultivators in several villages in his Tahsil construct bunds to confine the water within an enclosed space, and so procure the yield of better produce. Their efforts are often successful. The process adopted in this Tahsil for fertilizing the land is that the zamindars make enclosures round such plots of land as have a large admixture of manure, and do not yield a fair produce and collect water within the enclosed area. This water rots the manure in process of time and renders the soil capable of giving a crop. This practice is more frequently resorted to in the southern parts of this Tahsil, where much of the soil is of the *mar* class.

9. The Court of Wards Manager reports that nearly 20 bunds have been constructed on the estate of the Raja Bara, which is under the management of the Court of Wards, with the object of preventing erosion by drainage. All of these works have proved successful. The process adopted by the cultivators of the said estate for fertilizing land by deposit of soil is that they first make a bund at the end of a sloping field on the side of the declivity with a view to check the flow of water, and then cut some earth from the higher side and throw it on the lower. They thus reduce the surface of the whole field from a slope to a level. The advantage of this is that the upper part of the field which would have, but for this process, soon become dry and unfit for cultivation, remains as fertile and yields as good produce as the other parts of the field. This experiment has been tried with success in nearly 30 fields. The agricultural classes construct dams or bunds with three objects—

Bunds to Retain Water and Rot Manure.

(1) To rot the manure and to distribute it throughout the whole field to keep the field moist for some time and to let the soil get a sort of manure by the absorption of the saltish property of the water. To achieve these objects the cultivators surround their fields by fences and leave them for the water to collect therein during the rainy season. When the rains are over they make an opening on one side and let the water flow off. After this they let the soil dry up a little, and then plough it up and sow the seed. This process has been followed with success to a considerable extent on the estate of the Raja of Bara.

To kill *Kans* Grass.

(2) To rot the *kans* grass, which grows spontaneously in the fields. In the Court of Wards estate of Raghuraj Singh, in pargana Atharban, two plots of land suffering from the inroads of the kans have recently been surrounded by embankments and left for the rain water to collect therein and to rot the *kans*. The result of this experiment will not be known till the rainy season is over.

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Bunds to make Usar Land Fertile.

(3) To make usar (barren land) culturable. Bunds have recently, in accordance with orders received with Commissioner's No. 8382, dated 16th October 1892, been constructed round two plots of land in the Khargapur and Halagarh Government estates and the soil been ploughed up and left for the rain water to collect therein, with a view to endeavouring to make the soil culturable. The result will not be known till after the close of the rainy season.

Extract paragraph 43 of the Assessment Report of pargana **Banda.**

Conf. with p. 16.

43. Of all improvements within the reach of the mass of the inhabitants of the district, the most practicable and the most useful is the construction of embankments. These may be raised in any land and under all circumstances; but here again the level már plain is a less suitable locality for the expenditure of capital than any other. An embankment on a nearly level már plain prevents the water that falls upon the field from escaping, and is thus beneficial under certain circumstances, more especially in dry years. But if the rainfall is plentiful such embankments are not required, and the water has to be got rid of, and this is only possible by inundating adjoining fields.

Marvellous Improvement through Embankments.

But where the land is light and poor the additional supply of water is nearly always welcome, and when the slope is considerable the embankment prevents the soil being washed away and accumulates fertilizing particles from above. In the southern parganas of this district the improvement effected by embankments is marvellous; barren ravines and stony water-courses have been changed into fertile fields, and what appears from a distance to be a wilderness of broken country is found on closer inspection to be interspersed with green fields on a lower level, which have been effectually reclaimed. Banda is in this respect not capable of comparison with Badausa, and it is likely enough that the spontaneous fertility of the soil has had the not unusual effect of deadening the energy of the inhabitants, which harder circumstances have elsewhere so effectually stimulated. But if in Banda the ravine country has not been so systematically improved as elsewhere, this pargana takes the lead in the size of its embankments and the extent of land which they improve, and also in the more skilful method in which the surplus water is drawn off. In villages such as Ruvai Sunecha and Basahri, the embanked fields sometimes extend to from 20 to 30 acres; the embankments are high and massive, and when land is wanted for the plough the water is drawn off through masonry sluices, not solely through cuts in the bank. But although, since the new assessments have been given out, great progress has been made, enormous improvement is still practicable, and it may be hoped that, under the more favourable conditions which now prevail, a kind of improvement which is as yet general only in the villages to the south within a few miles on either side of the Ken, will be practised wherever light and uneven soils afford opportunities of effecting what is unquestionably the most useful as well as the most practicable improvement which is within the reach of the average proprietor or cultivator.

Embanked fields 20 to 30 acres.

The effect of embankments upon the natural soil is to improve its quality. Rákar becomes parna, or it may be, according to the neighbourhood, már or kabar, and the poorest parna is enriched and strengthened.

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Extract paragraph 55 of the Settlement Report of ***Banda District.***

In Black Soil Embankments not necessary.

A most creditable feature of the agriculture of the district is the number of field embankments varying from the slightly raised field border, which the cultivator can construct in a few days, to the extensive dam flooding 20 or 30 acres, and forming a considerable lake until the water is drawn off to render possible the ploughing for the rabi. Embankments such as those described were at one time more or less common all over the district; but to the north of the town of Banda, in the portion of the district corresponding generally with the black soil tract, they had been of late years generally neglected. In several villages, indeed, of Pailani and Augasi large embankments had been breached, and the once level fields had become cut up by water-courses. But in Pailani, beyond the Ken, embankments were fairly numerous, and in most black soil villages there were some fields with the raised borders which are all that are requisite in level neighbourhoods. And in black soil tracts embanked fields are so little necessary that there is but little inducement to construct them, except as a remedy for kans. In good level már embanked fields are no advantage in seasons of plentiful rainfall, and even in seasons of defective rainfall the land can ordinarily do without them. And where the lighter soil is limited in extent it is used mainly for kharif crops, and embankments are not greatly required. To the south and west of Banda, however, the surface is broken, and in the neighbourhood of Mataundh embanked fields were numerous, and nowhere throughout the district were they more permanent and substantial. The best of them with masonry sluices benefited large areas of 10, 20, and 30 acres. On the other side of the Ken, in Banda, and in the north of Sihonda, embankments were less numerous, and in this neighbourhood there is great scope for improvement; but to the south of the old pargana of Sihonda, in Kahiyar, now incorporated with Sihonda, and throughout the uneven portions of Badausa, embankments had been constructed with a persistent industry, which was in the highest degree creditable to the inhabitants. Until one sees the never-ending succession of embankments, which have created fairly fertile fields in the midst of broken ravine country, it is difficult to realize that such barren looking tracts are capable of the improvement which has been effected. What a few years ago were sandy ravines or stony water-courses become after a time fairly fertile fields. Even in hopelessly stony looking country below the hills hamlets have been planted since last settlement, and generally owing to the good management, energy, and enterprize of a lessee, extensive areas have been won from the jungle.

Character of Ravine Embankments highly creditable.

Conf. with p. 15.

Note by the Assistant Director on the making of Bunds in Rewah and parts of ***Bundelkhand.***

Nature of the country.—There are numerous hills and forests all over the country with streams flowing from them in various directions.

Sites of the bunds.—Large areas of moderately level lands, say from 1 to 20 acres in extent, around the streams are enclosed by earthen embankments at the foot of the hills or in proximity of the forest, small enclosures being called Bandhiá or Bandhi and larger ones Bandhwá or Bándh.

The bund.—The height of the embankment varies from 1 to nearly 8 feet, according to quantity of water to be received into the enclosed area. The top width of the embankment varies from 1 to 4 feet and the side-slopes from nearly $1\frac{1}{2}$ to 1 to 3 to 1 according as the soil is clayey or

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sandy, and also according as the flow of water is slow or rapid. The embankments have an opening towards the hill or forest side through which the stream enters the enclosed area. In certain cases a single enclosure suffices to hold all the water brought by the stream, but in others a chain of enclosures has to be constructed on different levels in ter aces along the course of the stream, the latter filling up each enclosure one by one till it is exhausted. The second method is adopted when the stream passes through tracts of land, all of which either does not belong to a single individual, or has abrupt rises and falls at short distances, the nature of the locality thus not allowing of construction of single enclosure large enough to contain all the water the stream would bring.

Ravine Deposits.

Silt.—The water of the stream carries with it in solution and suspension large quantities of highly oxidized detrital matter from the hills, dungs of animals and birds, matter derived from the dead bodies of insects and other animals, and decomposed leaves shed on the uplands and the valleys during the preceding winter and summer. The silt brought by the stream is thus extremely rich in manurial matters, and the land on which it is deposited is fertilized to a considerable extent.

After the rains are over a second opening is made in the embankment on another side, and the water left in the enclosure allowed to run out.

Crops.—Two or three ploughings are then given to the land, and a rabi crop, mostly wheat, is sown in lines by means of a bamboo seed drill. If the water standing on the land is shallow, an extra crop of paddy is also raised during the monsoon period.

Objects.—The chief objects of the practice are—

(1) to enrich the land by deposit of silt ;

(2) to destroy weeds by allowing water to stand on the land for a period of nearly four months, during which the roots and seeds of weeds die out.

The destruction of eggs and grubs, most of insects injurious to agricultural plants, also necessarily results from the practice.

Rents on the improved land.—The rent of such improved lands is sometimes ten times as much as that of ordinary lands.

From the Chief Secretary to Government, North-Western Provinces and Oudh, to the Secretary to the Government of India, Revenue and Agricultural Department,—No. 2724, dated 21st September 1893.

In continuation of my letter No. 2671, dated the 16th September 1893, I am directed to submit, for the information of the Government of India, a copy of the Director of Land Records and Agriculture's letter No. $\frac{T.334}{V.-46}$, dated 20th September 1893, with enclosures, in original, containing further information as to the action taken to promote the construction of dams and bunds for purposes other than irrigation.

Letter No. T.334–V.-46, dated 20th September 1893, from the Director of Land Records and Agriculture, North-Western Provinces and Oudh.

In continuation of my letter No. $\frac{T.325}{V.\ 46}$, dated 14th September, regarding the construction of bunds for purposes other than

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irrigation, I have the honour to forward, for transmission to the Government of India, copies of the following papers:—

(1) A note by Babu Lachman Persad on his reclamation operations near Cawnpur. This has been drawn up as the experiment in question has been specially noticed in Dr. Voelcker's report.

(2) Extract, paragraphs 2 and 3, of letter No. 2561, dated 9th September 1893, from the Collector of Jhansi.

(3) Extracts from the reports of the Superintending Engineer on the Jhansi embankments.

(4) Extract from paragraph 29 of Mr. Cadell's rent-rate report on pargana Badausa.

Note on the Improvement of ravine land in **Gotaya** *and* **Likhanpur.**

Reclamation in Ravines by Embankments.

The land included in my farm chiefly consists of the ravine land of two villages, Gotaya and Likhanpur. The land of the former village measures 25 acres. Up to 1883, it formed part of the Government farm and the Government used to pay R50 for it. It was used merely for raising fodder for the farm cattle and no experiment was conducted on it. Its surface was very sloping and cut up by ravines with hardly any boundaries to stop the rush of rain-water and prevent the washing away of the fine particles of sand; and it was only in years of pretty heavy rains that it yielded any crop worth the name: so in 1883, partly on account of its outlying condition, and partly owing to the poverty of its soil, it was given over by Government, and the zemindar leased it to a number of cultivators, who owned occupancy land in another part of his village, for a lump rent of R32. They, however, took it very reluctantly, and under pressure from the zemindar. Canal water was available at a short distance from this piece, and a considerable portion could be watered flush if it was only led to it by a channel. The land in the other village had a large expanse of waste land, extending over more than 125 acres, without a single hut or house, with two small pieces owned by *muafidars*, one by an occupancy tenant who lived in a remote part of the same village and held about 5 acres, while about 10 acres were held by 3 *pahi* cultivators from Nawabganj, a village in the neighbourhood. All these tenants paid lump rents which fell at the rate of R3 an acre. Excepting a small portion which had black *marwa* soil, the entire area of this piece had a light loam and differed in no respect from the other piece already described.

2. Both pieces admitted of an easy management; all that they needed was to stop the further erosion of the fine particles of their soil by dividing them into fields of suitable size, levelling the surface of each field thus formed, construction of channels to lead the canal water to the different parts of the two pieces, application of a little manure, and the settlement of a small hamlet, to have a number of cultivators on the spot ready to cultivate the land.

In 1885 I accordingly obtained a lease for 22 acres in Likhanpur, which was then, as a Ward's estate, under his management, at

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R2 per acre. In the same year I took 25 acres of Gotaya land for R50, laid the foundation of a hamlet on a high mound in the Likhanpur land, laid out roads, constructed distributaries for leading canal water, divided the land into fields varying from $\frac{1}{10}$ to 1 acre in size, and commenced to level their surface. A map showing the configuration of the land and the laying out of the different fields, roads, etc., accompanies.

Reclamation in Ravines by Embankments.

3. The work which these operations offered and the tolerably good crops which the canal water helped them to raise on levelled land, soon induced the labourers to bring their families and settle in the new hamlet. The rapidity with which the hamlet developed, and the demand which it created for land, led me to apply for more land, till it now comprises 156 acres leased from zamindars at R490 and let out to cultivators at an annual rent of R783.

4. I kept no systematic account of the various expenses that I incurred in the construction of roads, channels, houses, and in the levelling of fields; but roughly the cost of levelling conducted on an area of about 50 acres amounted to about R3,000. A bund was also thrown across one of the ravines to turn it into a sort of lake for the cultivation of *singhara* and for using its water for the irrigation of spring crops; but it was not thick enough to stand the fury of rain-water and was washed away in one night in 1891, before the earth had time to settle down. The terracing has, however, been so far successful that the same land for which cultivators at one time grudged to pay R2 an acre now easily lets for R8, and the difference of R293 between the rent at which it is leased to cultivators and the rent paid to zamindars practically represents the enhanced value of the 50 acres of levelled ground, which amounts to an interest of about 10 per cent. on the sum spent in levelling. A great deal of this success no doubt depended on the existence of canal water, without which an amount no less than the cost of levelling would have been needed to be sunk in wells before the land could be made to yield its present rent. I have no hesitation in recommending the improvement and to a certain extent reclamation of ravine land by terracing, costing R60 to 80 per acre, wherever canal water is available. **Mr. Holderness**, when leaving the Department in 1892, observed as follows on the success of terracing the ravine land: "You have clearly shown that by embankment and a very moderate outlay on manure, it is easily possible to improve broken and apparently sterile land and convert it into fertile fields. Until I saw your work I had not realized how valuable the simple expedient of embankment is."

Extract paragraphs 2 and 3 of a letter No. 2561, dated 14th September 1893, from W. Grierson Jackson, Esq., C.S., Collector of ***Jhansi****, to the Director of Land Records and Agriculture, North-Western Provinces and Oudh.*

Conf. with Remarks, pp. 13 & 24.

2. A large number of small embankments, locally known as *bandhias*, have been constructed by the zemindars in various parts of this district,

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Embankments to flood & kill *Kans* Grass.

and *takavi* has been freely given to assist in the work. These *bandhias* are inexpensive works, not more than two or three feet high. They are usually constructed for the purpose of retaining water and drowning out the *kans* in a small area, and they appear to afford the best means within the ability of the petty landholder of coping with this evil. They are also used in some instances to prevent surface erosion, and to promote the deposit of better soil. In each case their use is limited to localities where there is a perceptible and continuous slope of the surface of the country, the bandhia being limited to the lower edge, and as much of two sides as may be necessary of the plot to be protected.

3. Certain works on a larger scale were undertaken at the cost of Government in the vicinity of the village of Raksa, in the recently ceded territory, which may be described as slightly magnified bandhias, intended to hold up the surface water in a tract of ravine country, to prevent further erosion, and to promote the silting up and subsequent reclamation of the land behind the bunds. These works were reported on by MAJOR CORBETT, then Superintending Engineer for Irrigation, in 1890. It was then decided that the degree of success obtained could not be estimated until the experiment had been watched for a number of years, and the bunds were made over to the Irrigation Department for that purpose. The immediate prospects were not considered sufficiently promising to warrant an extension of the area under treatment.

Extracts from Report of Colonel Corbett, R.E., Superintending Engineer, Irrigation Department, on the **Jhansi** *Bunds.*

Report of 18th September 1889.

"The bunds were made 6′ wide at top, up-stream slope 3 to 1, down-stream 2 to 1. They are generally $3\frac{1}{2}'$ above site of waste weir, and are pitched about the waterline to protect from 'lap.' This pitching will have to be continued as water-level becomes lower, but it costs very little.

Bunds in Ravines.

"The waste weirs of the chief reservoirs have a length of site of something like 80′ per square mile of catchment area. They are perfectly safe and cost next to nothing. There is no doubt that in ravines of this description the system of *bunds* can be made safe at a moderate figure."

The report then points out that too many *bunds* had been made, and that in place of R8,500 actually expended up to that time, R6,500 would have been sufficient.

"The results can be far better judged a few months later in the season, but it seems certain from the experience of last season that there will be some water left (available for watering cattle) up to the beginning of the next rains. Also that the bed of the ravines, *as far as affected by percolation*, will grow grass or crops, and, where the depth of soil is sufficient, trees. The width of the strips affected by percolation is apparently not great.

"The *bunds* at the heads of ravines will certainly cause a deposit of silt, and their reservoirs will in time be filled up. The same will happen to the lower ones in time. In my opinion the best chance of a direct return will be from the cultivation of the upper reservoir sites during *rabi* and from grazing."

Report of 29th December 1890.

"It appears to me, after walking nearly all over the ravines, that the area outside the tanks that can be beneficially affected by the *bunds* is

N.-W. P. & OUDH. Returns from Ravine Bunds.

very small. As before stated in my report of September 1889, I think some return for the expenditure incurred may be expected from the areas now covered with water; they will silt up in time and bear strong *rabi* crops. Some of the tanks show considerable deposit already.

"I can see no likelihood of an adequate return for the money spent in the construction of these *bunds*, but they should, I think, eventually yield something more than their up-keep, which can, I believe, be reduced to R100 per annum now, and in a year or two more to R50. No more works of this description should be undertaken at present, but sufficient attention should be given to the existing works to ensure the safety of the *bunds*.

"The experiment cannot be considered concluded till many more years have elapsed, but the annual cost of maintenance can, I believe, be kept very low."

Extract from paragraph 29 of Mr. Cadell's Rent-rate Report on Pargana Badausa, District **Banda.**

Conf. with pp. 16 & 22.

"Until one sees the never-ending succession of embankments which have created fairly fertile fields in the midst of broken ravine country, it is difficult to realize of how much improvement such barren-looking tracts are capable. What are one year sandy ravines or stony water-courses become after a time, owing to the construction of embankments, fairly fertile fields, and it is highly creditable to the people of this, which is naturally the poorest pargana of the five with which we have had to do, that such great improvement should have been effected. What I have heard longed for, as a possible achievement in the broken country which fringes the fertile upland of the upper Doab, is here realized in a comparatively unnoticed pargana of backward Bundelkhand."

V.—PANJAB.

PANJAB.

From J. M. Douie, Esq., *Offg. Revenue Secretary to the Government of the Panjab, to the Secretary to the Government of India,—No. 1078 S., dated Simla, the 14th October 1893.*

Forwards for the information of the Government of India, a copy of a letter No. 443 C., dated 13th September 1893, from the Financial Commissioner, and enclosures, from the Director of Land Records and Agriculture.

Letter No. 1536, dated the 31st August 1893, from E. B. Francis, Esq., Director of Land Records and Agriculture, Panjab.

In reply to the Government of India Circular No. 23—113, of 21st June last, received with Panjab Government's endorsement No. 86 of 10th July last, on the subject of the construction of embankments

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and dams for purposes other than that of irrigation, I have the honour to state that such works are constructed by the peasantry themselves on a large scale in the Daman country between the Suleiman Range and the west bank of the Indus, and on a smaller scale in the lower parts of the Salt Range in the Rawalpindi and Jhelum districts. I have obtained brief reports from the Deputy Commissioners of those districts, which are herewith forwarded in original. Important reclamation works are also in progress on the banks of the Indus, on which subject the Deputy Commissioner of Dera Ghazi Khan has sent a note by **Mr. R. A. Molloy**, Executive Engineer, Indus Canals.

Deputy Commissioner, Rawalpindi's No. 1499 G., dated 3rd August 1893. *Below.*
Deputy Commissioner, Dera Ghazi Khan's No. 1052, dated 14th August 1893. *Page 29.*
Deputy Commissioner, Jhelum's No. 665, dated 17th August 1893. *Page 31.*
Deputy Commissioner, Dera Ismail Khan's No. 1190, dated 23rd August 1893.

Ravine Embankments.

2. It appears that the Daman dams mostly have irrigation for their primary purposes, but are also useful in inducing a deposit of silt over the lands watered. Long earthen embankments are thrown across the bed of torrents at the point where they emerge from the hills, and the water (which comes down only after heavy rain) is thus intercepted and distributed over the lands on each side. Such embankments often fail through leaks started by rat holes or cracks. Earthen embankments and spurs are also often made to prevent erosion of the banks of the larger torrents.

Indus Embankments: (a) Protective. (b) Reclamation.

3. The Indus works are of two kinds—(1) protective embankments to defend low cultivated lands from the attacks of the river, and (2) reclamation works which consist of dams thrown across side channels of the river for the purpose of cutting off the stream and so causing the channels to silt up. These works have so far been very successful, as was noticed in the Revenue Report for 1891-92 (see paragraph 20 of the Government Review), but the Engineer in charge notes that as they were commenced only four years ago there has not yet been time enough to develop their full effect, and that it is too early to compile a full account of the undertaking.

Salt Range Field Bunds.

4. In the Salt Ranges the embankments are made field by field, and have some resemblance to the terracing work which is carried out on the sides of the Himalaya for the purpose of retaining the soil upon steep slopes. The Deputy Commissioner of Jhelum reports that over R25,000 have been advanced under the Agricultural Improvements Act during the last five years for such embankment works. No similar advances have been given in Rawalpindi.

From H. B. BECKETT, Esq., *Deputy Commissioner,* **Rawalpindi**, *to the Director of Land Records and Agriculture, Panjab,—No 1499 G., dated the 3rd August 1893.*

With reference to your No. 1270, dated 19th ultimo, forwarding for report Government of India's Circular No. 23—113, dated 21st June 1893,

I have the honour to state that no action has been taken in recent years in this district to promote the construction of bunds for other purposes than that of irrigation.

2. The practice of constructing such bunds, however, prevails to a considerable extent among the agricultural classes here, though no *takavi* has been granted for the purpose for some years past.

From M. L. DAMES, Esq., *Deputy Commissioner,* **Dera Ghazi Khan,** *to the Director of Land Records and Agriculture, Panjab,—No. 1052, dated Dera Ghazi Khan, the 14th August 1893.*

In reply to your endorsement dated 19th July 1893, calling for a report on the subject of dams or bunds for other purposes than irrigation in accordance with Circular No. 23—113, dated 21st June 1893, from the Government of India, Revenue and Agricultural Department, I have the honour to report as follows:—

1. There are two systems of dams or bunds in use in the Dera Ghazi Khan District, which may be roughly distinguished as Pachadh Bunds and Indus Bunds:

Bunds on Ravines of Suleiman Mountains.

I.—The Pachadh (or west) is the strip of country lying to the west of the district immediately under the eastern slope of the Suleiman mountains. Further north, in Dera Ismail Khan, the corresponding tract is known as the Daman or 'Skirt.' This tract is entirely dependent for irrigation (except in the case of a few permanent streams) upon the water of the large and small hill torrents which only run when rain falls in the hills. The distribution of this water is effected by a very elaborate system of bunds. Of course the main purpose of these bunds is irrigation, but incidentally they serve two other purposes, *viz.*, (*a*) the prevention of erosion, and (*b*) the enrichment of the land by the deposit of silt. For both these purposes the system is a very efficient one. The hill torrents in the north of this district and in Dera Ismail Khan runin deep beds cut through a friable soil, and when they are in flood they have a strong tendency to cut back, and their tributaries and nullahs formed by local rainfall tend to spread back into a series of ramifications which render large areas worthless, and sometimes destroy inhabited sites. The village of Diara Shah (where a celebrated shrine is situated) near Taunsa in the Sanghar Tahsil has long been threatened with destruction in this way, but has hitherto been preserved by throwing a bund across the channel. In heavy floods, however, where the channel is deep and the current violent, these bunds are often destroyod, and sometimes it is found impossible to re-erect them owing to the scouring out of the channel.

For irrigation purposes bunds are generally thrown across the beds where they are broad and shallow, close to the point where they emerge from the hills.

Native Method of Forming Bunds.

These bunds are entirely of earth and are constructed generally by a combination among the villages benefited which comes under the supervision of the Deputy Commissioner when necessary. Every village gives a quota of oxen and 'khens.' The 'khen' is a wooden board with a handle which is held in an upright position by the driver and drawn by a yoke of oxen. With these instruments the earth is scraped up rapidly, the bund being at the same time consolidated by the trampling of the oxen. Many hundred yokes may be seen working in this way on the larger joint embankments, and the system is a very efficient one.

These bunds distribute the water and at the same time prevent erosion of the main channels. Through a series of canals and branches the

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water is distributed according to a carefully recorded system of rights, and finds its way into the fields. Each field is surrounded by a bund of its own, and in fact the word ' bund ' is used as an equivalent for a field of this sort. It is here that the second subsidiary object of the system is seen, *viz.*, the deposit of silt. Every ' bund ' or embanked field is raised high above the natural level of the country owing to the perpetual deposit of silt. The water of the hill torrents is thickly charged with this deposit, and a depth of from three to six inches is often deposited over the whole area of a ' bund. ' This is most fertilizing and takes the place of manuring on these lands.

Silt Deposits.

Earthen embankments and spurs are also often thrown up to prevent erosion of the banks of the larger torrent by diversion of the current from the threatened spot as well as by silting up. In such cases the spur only extends part way across the bed of the torrents. They answer often the double purpose of diversion and silting, as, when the current is diverted, a back water is immediately formed in the angle between the spur and the bank, in which silt is deposited. By such means the town of Taunsa and the Baloch fort of Lalgarh have been preserved from destruction by the Sanghar and Kaha streams.

Indus Valley.

II.—The other system of bunds is along the low land of the Indus Valley, known as Sindh. These are not carried out by the people themselves, as in the Pachadh, but are entirely managed by officers of the Public Works Department. The same method of construction (*viz.*, by oxen and ' khens ') is, however, followed. These bunds again may be divided into two classes—Inundation Bunds and Reclamation Bunds. The first are simply embankments for protection of low-lying parts of the country from the floods of the Indus. As to the second, I enclose a note from Mr. R. A. Molloy, Executive Engineer, Indus Canals, under whose supervision the reclamation bunds have been constructed. Those that have been constructed have certainly proved very successful, both in preventing erosion and in causing silt deposits. The principle followed is to close ' the Dhands ' or side creeks of the Indus by embankments thrown across them in the cold season when they are dry, and thus to confine the river in the flood season to its main channel and to cause the flood water to deposit its silt over the flooded areas, which lie between the main stream and the inundation or protective embankments. Thus the high bank, the inundation embankments and the canal heads are protected from erosion, and the *sailaba* lands (*i.e.*, lands dependent on flood irrigation) are enriched. The proceedings of the Committee alluded to in the first paragraph of Mr. Molloy's note may be consulted on this point. The system is alluded to with approval in paragraph 20 of His Honour the Lieutenant-Governor's Review of Revenue Report for 1891-92.

Note on the subject of Reclamation Bunds of **Dera Ghazi Khan,** *by* Mr. R. A. Molloy, *Executive Engineer, Indus Canals, dated 1st August 1893.*

The reclamation bunds constructed in this division at various points along the right or west bank of the Indus from 20 miles north to 40 miles south of Dera Ghazi Khan have been undertaken in pursuance of the recommendations of the Committee ordered in the Panjab Government's No. 417 C., dated 15th August 1889.

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2. Their object has been (1) to check the erosion of the west bank by the currents of the river, and (2) to reclaim a foreshore. It was anticipated that the reclaimed land would be fertilized by deposits of silt, but this result was not the primary object in view, which was the protection of the irrigated tract inland.

Considerable Areas reclaimed.

3. In the report of the Committee it was pointed out that this process of reclaiming the foreshore would necessarily be gradual. It was only commenced four years ago. Considerable areas of land have been reclaimed along the west bank ; and of this area a considerable portion have been fertilized ; but there has not been time for the operations to develop their full effect, and still less time for full information on the subject to be compiled.

4. As to the practice of the agricultural classes in constructing such dams, some information is given on page 119 of the Gazetteer of the Dera Ismail Khan District.

5. The reclamation bunds now being constructed along the west bank appear to be merely a development of this similar practice along the east bank higher up the river in the Dera Ismail Khan District, and the effect will be the building up of a "*katchi*" or fringe of *sailaba* land in front of the protective embankments behind which lie the irrigated lands.

From J. G. SILCOCK, Esq., *Deputy Commissioner*, **Jhelum**, *to the Director of Land Records and Agriculture, Panjab,—No. 665, dated the 17th August 1893.*

Large number of Bunds constructed.

With reference to your No. 1270 of the 19th July, I have the honour to inform you that a very large number of bunds have been constructed in this district for the purposes of prevention of erosion and to fertilize the land by deposit of soil. These bunds are constructed and maintained by the agriculturists themselves, and it is in fact the only way in which a great portion of the district, which is chiefly hilly, can be cultivated. These bunds are as a rule small and easily constructed and repaired by the zamindars, and do not need any detailed description. In the last five years the zamindars have taken *takavi* to the extent of R25,545 for construction of new bunds.

Heavy rains, such as those which have occurred during the last two years, are very destructive to these bunds, but they are generally all repaired after the rains for the cultivation of the *rabi* harvest.

The District Board have constructed a few large bunds throughout the district, but these are mainly for the storage of water on roads where water is scarce.

From L. W. KING, Esq., *Deputy Commissioner*, **Dera Ismail Khan**, *to the Director of Land Records and Agriculture, Panjab,—No. 1190, dated the 23rd August 1893.*

I have the honour to report as follows with reference to your endorsement No. 1270, dated 19th July 1893, on subject of the construction of dams or bunds for other purposes than that of irrigation.

Ravine Bunds.

2. No embankments of the nature indicated in the Government letter under reference exist in the cis-Indus Tahsils of the district (Bhakkar and Leia), nor do they seem to be required. In the Daman tract of the trans-Indus Tahsils (Dera, Kulachi, and Tank), however, the case is different. Here the country is to a great extent cut up in all directions by ravines

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(the result of the action of hill torrents) which form deep cracks in the otherwise level surface of the ground. The zamindars have accordingly in such localities been encouraged to construct small bunds across these ravines which, if they stand firm, serve the double purpose of preventing further damage by erosion and of rendering the land culturable by filling up the cracks with a deposit of silt.

3. During recent years the following works of this description were undertaken :—

Enumeration of Chief Bunds recently constructed.

Kulachi Tahsil.

1. Gatta Sahib Ramwala in the village of Takwara.
2. Sad Garku in Nutkani village.
3. Sad Khubezai.

Tahsil Tank.

4. A "sad" or bund in the Jamal Awan village.
5. Ditto in Garah Mamrez village.

Dera Tahsil.

6. Sad or bund in the villages of Sikandar and Haindan.
7. Ditto in Tikon.
8. Ditto in Kotla Habib.
9. Ditto in Fatteh.
10. Ditto in Nun and Nawab.
11. Ditto in Draban Khurd.

Unsuccessful Reasons attributed.

It is a matter for regret, however, that all these "bunds" proved unsuccessful, except Nos. 1 and 2 which stood firm and achieved good results.

The failure in the other cases is attributed to the following causes :—

(*a*) The zamindars, owing to poverty and disunion, are unable to construct bunds sufficiently strong to resist the impetuous rush of the water from the hill torrents.

(*b*) Sometimes "noons" or leaks occur in the bunds which are difficult of detection at first and are afterwards almost impossible to stop. These, if remedial measures are not taken in time, almost invariably lead to the destruction of the dam. To prevent the occurrence of those leaks it is necessary to be always on the watch, and zamindars are as a rule too lazy and apathetic to undertake the trouble which this involves.

As far as my experience goes, these leaks are due to the following causes :—

(*a*) Old bunds are frequently perforated with the holes made by field rats, which sometimes (if not stopped in time) lead to the formation of leaks.

(*b*) The clay in the Daman tract is generally of a hard texture, and so it often happens that in the process of construction a few large clods of earth are left in the bund. Interstices are thus formed between the earth of thebund and these clods which let in the water and thus give rise to leaks.

(*c*) The bed of the ravine is generally composed of silt which, when exposed to the sun's rays, becomes intersected by deep cracks. If in erecting the bund earth is thrown over these cracks, a way is left for the water to work its way out, and in this manner leaks are often formed.

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During the current year in the case of irrigation bunds the experiment has been tried, and with excellent results, of clearing away the silt foundation before the construction of the bund is commenced.

VI.—CENTRAL PROVINCES.

CENTRAL PROVINCES.

From H. H. PRIEST, Esq., I.C.S., *Secretary to the Chief Commissioner, Central Provinces, Revenue Department, to the Secretary to the Government of India, Revenue and Agricultural Department,—No. 4516, dated Nagpur, the 26th September 1893.*

Submits a copy of letter No. 3094-74, dated the 21st September 1893, from the Commissioner of Settlements and Agriculture, containing the information collected by that officer on the subject.

Letter No. 3094-74, dated the 21st September 1893, from J. B. Fuller, Esq., I.C.S., C.I.E., Commissioner of Settlements and Agriculture, Central Provinces.

I have the honor to submit the following report on the questions connected with the embankment of land, which are raised in Government of India's Circular No. $\frac{23}{113}$, dated 21st June 1893.

2. It will be convenient if I reverse the order of the heads under which information is required, and to state first of all how far the embankment of land is practised in these Provinces, and in the second place how far the practice has been promoted by Government.

Embankments in Rice Cultivation.

3. The tracts in which embankments are most largely used are the rice districts of Chhattisgarh and the Wainganga valley. The embankments are here merely to provide the rice crop with water by retaining or distributing surface drainage. They are in fact irrigational works, and are not of the class to which the Government of India refers.

Jabalpur. Imprisonment of Surface Water, in Wheat Cultivation.

The best example of land embankment other than for rice cultivation is given by the central portion of the Jabalpur district, where long stretches of country are divided up into compartments by substantial earthen banks which are generally from 3 to 4 feet high and often very much higher. In this way the greater part of the surface drainage is imprisoned, and during the latter part of the monsoon the fields are deep in water and the aspect of the country is as though submerged by a flood. The water is drained off as the autumn advances and in October year after year the fields are uniformly sown with wheat. Land so embanked bears a particular name in this locality (*Bhandhwas*) and is of much greater value than unembanked land. The retention of the surface water benefits the fields in several ways. It prevents the erosion during the monsoon to which fields of fine

Advantages of Bhandhwas Embankments.

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black soil are peculiarly liable, it keeps the land clear of weeds, it brings out the effect of any manure which may be applied and it renders the land quite independent of October rain, the rain which is at once the most precious and most capricious in the year. Moreover, advantage is generally taken of the flooding to grow a little rice during the monsoon season which is cut before the wheat sowing time comes round. But this rice cultivation is unimportant, and it is for its wheat crop that the land is valued. The embankment is generally supposed to add at least 25 per cent. to the produce, and cases commonly come to notice in which the outlay of several thousands of rupees is recovered in a few years from the increase in produce. The embankments of land on this system is extremely local. Its centre is the strip of open country which runs parallel to the line of railway down the middle of the Jabalpur district. In the two western tahsils of this district the embanked area amounts to over 70 per cent. of the total. The practice extends northward into the hill valleys of the Damoh district and southwards over the bay of good land left by the Nerbudda on which the town of Mandla is situated. Westwards it extends a short distance into the Narsinghpur district where one pargana (Srinagar) on the Jubbulpore border is very largly embanked. The practice is thus confined to a connected tract of country outside of which it is very rarely found. Embankments of very similar character are met with in the Southern and Eastern districts, but they are mainly constructed for the growth of rice, and if *rabi* crops are grown they follow the rice as an after crop of subordinate importance.

Causes increase of 25 per cent.

There can be no doubt that for the successful embankment of wheat land on this system several special advantages are required. The ground must be fairly level, the soil must be of fine texture such as is bound by water, the rainfall must be heavy, and it is probable that certain conditions as to sub-soil must be present. The land must enjoy special advantages and its embankment is a means of utilizing t' em. It would be a mistake to imagine that the great mass of the black soil wheat lands of the Provinces could be profitably converted into *bhandhwas* land. At the same time it seems clear that embankment in the Jubbulpore style is spreading on the margin of the tract in which it is now practised. In the Jabalpur district there is hardly room for new embankments, as for many years past they have been already made on all land suitable for them. But the Deputy Commissioner of Narsinghpur shows that embanked lands are extending in the eastern part of the district. And the Settlement Officer of Jubbulpore reports that the embankments are now not uncommonly improved by the addition of masonry escapes which increases the cultivator's control over the water.

Conditions necessary for this System of Embankment.

Not suited to all Wheat Soils.

Masonry Escapes.

4. For *bhandhwas* land a certain evenness of slope is required. But embankments are commonly made on very uneven land which they improve by silting as well as by the retention of water.

Embankments to check Erosion.

Banks of this kind can be used for isolated fields, whereas one of the conditions for the success of *bhandhwas* fields is that they must

CENTRAL PROVINCES.

form part of a connected series. And as they do not require such special advantages in soil and position, they can be made over a very much larger area. In principle they do not perhaps differ much from *bhandhwas* embankments. In some cases it is true they are made to keep surface water off the land, but generally their object is to retain it. I think, however, that it may be said that they benefit the land rather by stopping erosion and silting up inequalities of surface than by the storage of water, whereas with *bhandhwas* land the opposite is the case.

Embankments to check Erosion and facilitate Silt Deposits.

Embankments of this kind are found to a greater or less extent in every district. They are of commonest occurrence on the borders of rice country, and are typical of the wheat lands of Pargana Bijeraghogarh at the extreme north, and of Chanda at the extreme south of the provinces. It is to their encouragement that the efforts of Government have of late years been principally directed, and there can be no doubt whatever that their construction is largely on the increase. They are least numerous on the extensive wheat lands of the lower Nerbudda valley (Hoshangabad) and the Nagpur plain, and *primâ facie* there are no localities in which they are more needed. The surface of the country is generally uneven and much intersected with water channels; most fields are traversed by a depression which during the rains is filled by a miniature torrent carrying away the finer particles of soil on which the production of the land so largely depends. It may be that the force of water is too great for check or that the soil lacks retentive power, and it would most certainly not be safe to ascribe the annual loss by surface denudation to nothing more than the apathy of the cultivators. But successful embankments are to be met with in these localities and the making of small protective works of wattle or stone seems to be increasing in localities such as the Nagpur district, where much of the soil is undoubtedly too friable to form embankments. It would be quite as unsafe to conclude that because the land has not yet been improved, it is not capable of improvement. Population is as yet far from dense, and farms are of large size, a substantial ryot commonly holding from 20 to 30 acres.

Government encourages Embankments.

5. Turning now to the action taken by Government to promote land embankment, I would invite attention to the correspondence with the Government of India on the subject of exempting improvements from assessment, ending with their letter No. $\frac{103}{29}$ R., dated 31st January 1888. Embanked land (however much its value may result from natural advantages) is not liable to additional assessment as being of superior class until the constructor has enjoyed the whole of the increase in profits for at least one whole term of settlement, and no trouble is spared to bring this home to the people in the course of the settlement operations now in progress by the preparation of attested lists of fields which are entitled to this concession. Printed notices of the policy of Government have been very widely distributed. Moreover, as a security against any error on the part of the Settlement Department in future years, all persons who have

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made embankments since 1888, have been declared entitled to receive a certificate protecting their increased profits from assessment at the succeeding settlement. It was anticipated that the grant of these certificates would of itself stimulate embankment, and this anticipation has already been to some extent realized. In the four districts of Saugor, Damoh, Jabalpur and Mandla, 808 certificates have been given for embankments during the past four years; and though this number may seem trifling in comparison with the size and population of these districts, it is sufficient to evidence that a start has been made and that the policy of Government is not unappreciated. The Deputy Commissioner of Saugor states that land embankment in that district is not customary, but is becoming more general and popular every year and he ascribes its extension to the growth of an idea amongst the people that Government wishes to see it extended and is desirous of encouraging it. Similar reports come from the neighbouring districts of Damoh, Jubbulpore and Seoni. I may mention that the extent to which land has been embanked in paragana Bijeraghogarh is usually ascribed to the policy of a former native ruler who made the construction of an embankment a title to the hereditary occupancy of the land embanked. In the Nagpur district, 41 certificates have been given out, and the Deputy Commissioner writes that they are much appreciated. In the neighbouring district of Chhindwara the number only reaches 21, but the Deputy Commissioner reports that the practice of embanking lands to stop erosion is gaining ground; and the Settlement Officer states that the issue of notices explaining that embankment would not entail an increase in assessment has led to a marked extension of the practice since 1889. Elsewhere very small use has as yet been made of certificates for land embankment. But it would be a mistake to regard this as an indication that land was not being banked. The popularity of these certificates largely depends on the manner of their introduction, and I was struck last cold weather with the large area of newly embanked land in a district (Raipur) in which only one certificate had been given out. Whether certificates are granted or not, there is a widespread impression that the Government views the embanking of land with favour; and it seems clear that this impression is acting as a stimulus.

Government Action stimulating People.

6. The loans advanced for land embankment under the Land Improvement Loans Act have not been considerable. During the last four years R16,000 have been advanced for this purpose in the Saugor district, R8,100 in Seoni, and R7,076 in Nagpur. These are the largest figures if we exclude the rice districts.

It should be added that in the Narsinghpur district the Court of Wards has set an example which has probably been of some effect, having spent nearly R10,000 on field embankment during the last four years. Elsewhere the Court hardly appears to have taken sufficient advantage of its opportunities, though injunctions for the investment of surplus funds in land improvement have been frequently issued.

BURMA.

VII.—BURMA.

From C. G. BAYNE, Esq., *Revenue Secretary to the Chief Commissioner of Burma, to the Secretary to the Government of India,—No. 383—3 I.-15, dated Rangoon, the 20th September 1893.*

Submits a copy of letter No. 258—479 R., dated the 11th September 1893, from the Financial Commissioner, on the subject.

Letter No. 258—479 R., dated the 11th September 1893, from the Secretary to the Financial Commissioner of Burma.

With reference to your endorsement, Revenue Department, No. 228—3 I.-15, dated 11th July last, I am directed by the Financial Commissioner to say that the information on the points referred to in Government of India, Revenue and Agricultural Department, Circular No. 23—113, dated 21st June, is still incomplete, as no replies have been received from the Commissioner of Northern and Central Divisions; but as the information is required at once, the Financial Commissioner has considered it advisable not to wait any longer for the reports from those divisions.

Very few Embankments except for Irrigation.

2. In no case, so far as is at present known, has any action been taken in recent years in Burma to promote the construction of dams or bunds for other purposes than that of irrigation, as described in paragraph 1 (A) of the Circular above referred to.

3. In no district except Pegu does the practice of constructing bunds or dams with the objects referred to in paragraph 1 (A) of that Circular prevail, but in some parts of Pegu cultivators do cause silt to deposit on their fields by keeping up high bunds or *kazins* round their fields while the rainfall is heavy. On these being cut to let the superfluous water flow off, there is found to be a deposit of silt which is an advantage. Each cultivator works for himself, and the people do not combine to build bunds of public utility. It is also said that in some cases in the Kyouktan Sub-division the people have erected bunds for the purpose of preventing erosion by drainage, but no particulars of the method adopted have been furnished, but it is said that the efforts of the people in this direction have been successful.

ASSAM.

VII.—ASSAM.

From the Secretary to the Chief Commissioner of Assam, to the Secretary to the Government of India, Revenue and Agricultural Department,—No. 360 Agri.—7524 R., dated Shillong, the 16th September 1893.

Forwards a copy of letter No. 4358, dated the 1st September 1893, from the Director, Department of Land Records and Agriculture, Assam, and enclosure,* furnishing certain particulars on the subject.

* Letter from the Deputy Commissioner, Sylhet, No. 399, dated the 18th August 1893; *see p. 39.*

ASSAM.

Letter No. 4358, dated Shillong, the 1st September 1893, from H. Z. Darrah, Esq., I.C.S., Director, Department of Land Records and Agriculture, Assam.

With reference to the Government of India, Revenue and Agricultural Department Circular No. 23—113, dated the 21st June 1893, on the subject of non-irrigation *bunds*, forwarded with your memorandum No. 287 Agri.—5134 R., dated the 10th July 1893, I have the honour to say that I consulted the Deputy Commissioners of the province on the subject, all of whom, except the Deputy Commissioner of Sibsagar, have sent in their replies. The Deputy Commissioners of Goalpara, Darrang, Nowgong, Naga Hills, Khasi and Jaintia Hills, and Garo Hills report that no action of any kind has been taken in recent years to promote the construction of dams or *bunds* in their districts for purposes other than that of irrigation. The Deputy Commissioner of Sylhet has sent me an interesting report on the subject, a copy of which is forwarded herewith. An abstract of each of the reports forwarded by the Deputy Commissioners of Cachar, Kamrup, and Lakhimpur is given below.

Cachar.—Of late years three *bunds*—one at Rangir Khari, another at Beth Khari, and the third at Katakhal in Tarapur—have been constructed with a view to prevent flood-water running into the adjacent paddy-fields and inundating the low-lying villages. These *bunds* have so far worked well.

Bunds to prevent Erosion.

Kamrup.—In 1890-91 action was taken by the Local Board to promote the construction of *bunds* with the object of preventing erosion by drainage in two places, *viz.*, one within the tahsil of Patti-Darrang and the other within the tahsil of TAMBULPUR, the former of which is reported to have become almost useless for the purpose for which it was erected, owing to a breach effected by some mischievous person. Steps have also been taken by the Public Works Department first to dam up the hill stream Kalmeli in the tahsil of Palasbari with the object of diverting its course for the purpose of supplying pure drinking water to the inhabitants of villages Ajhara and Kuli Kuchi; secondly, to erect a *bund*, about 300 feet long, on the south bank of the river Noanadi to prevent the influx of flood-water into the villages lying on the south side of the stream. The latter *bund* also prevents the erosion of the Gauhati-Nalbari road. As regards the local agriculturists taking any action in such matters, it is reported that some private individuals in mauza Batasgila within the tahsil of Nalbari erected a *bund* in April last on the western bank of the Noanadi with the two-fold object of preventing the influx of flood-water into their paddy-fields and the erosion of village roads and homestead lands. But this has since proved a failure owing to the *bund* having been recently washed away.

Lakhimpur.—In North Lakhimpur a sum of RS.000 was recently allotted by the Local Board for the purpose of repairing the *bunds* at Dhakuakhana, which is reported to have been since about half completed.

ASSAM.

From W. H. LEE, Esq., I.C.S., *Offg. Deputy Commissioner of Sylhet, to the Director, Department of Land Records and Agriculture, Assam, No. 399, dated Sylhet, the 18th August 1893.*

In reply to your No. 3867-77, dated the 26th July 1893, forwarding, for report, Secretary to the Government of India's Circular No. 23—113 of the 21st June 1893, I have the honour to state that the extensive district of Sylhet presents several very interesting problems in the matter of the control of flood-water. The district, though belonging administratively to the province of Assam, is geographically the head of the great deltaic country, Eastern Bengal. It consists (with the exception of scattered lines of hills) of low flat land, and is practically overflooded every year for six months during the rains. The great rainfall of the district (about 150 inches in the average) and that of the hills of Cachar and Lushai and the southern slope of the Khasi and Jaintia hills (upon which the highest rainfall in the world is precipitated) give to the Kusiara and Surma, which pass through the district, the strength of hill streams, and the amount of silt brought down is enormous. Practically nothing can successfully embank these rivers when in full flood, and they burst out over the surrounding marshes carrying silt with them. Sometimes the rush of water is sufficient to cause destruction to houses and crops, but this is rare. The rice grown here is mostly of a long kind, which thrives in deep water. It survives a slow rise of flood level to any practical extent, but a sudden rise submerges and destroys it. These facts make the question of embanking rivers one of the first importance.

Embankments to control Overflow of Rivers.

2. In 1887 an embankment was made along the Surma river to prevent the overflow of water from the Surma into the Kusiara, at a part a short distance up stream from Sylhet in the jurisdiction of the Golabganj outpost, where the Surma and the Kusiara rivers approach one another. I believe that this was constructed partly out of Provincial and partly out of Local funds. It cost R13,000. It was estimated by Mr. Kennedy, then Deputy Commissioner, to have saved crops to the extent of R30,000 in the one year, 1890. It was not entire, but had culverts to let off the water gradually. This year, during which the floods have been very high, the embankments have unfortunately broken, and the result is a sudden rise of water on the outflow side, submerging and destroying huge quantities of the rice crop. In 1892 an embankment was constructed along the Kusiara river to prevent outflow to the south. This is successful, but should be extended and provided with culverts. The problem in this case is that there is a row of unfortunate villages (Bargao, Katalipara, and others) along the south bank of this river, which are not affected by the ordinary yearly inundation of the country, but in time of high flood, such as occurs every four or five years, become converted into a sort of anicut, the bank being higher than the country to the south. The consequence is, that the overflow rushes like a mill-stream in a sheet of water bodily through the village, carrying everything detached away with it. Roads in this district are necessarily raised, and take the form of embankments. Most of these interfere objectionably with the natural drainage of the country, because, owing to the smallness of the Local funds available, they are insufficiently bridged and tunnelled. Some of them, as the river-face road at Habiganj along the Khowai, protect villages and subdivisional sites from erosion. In general it may be said that embankments in this district prevent, and do not promote, deposit of soil or silt. This is a matter of regret, since there can be no doubt that the agricultural prosperity of Sylhet is largely due (like that of Egypt) to this yearly layer of fertilising mud, and also that the level

Do not promote Silt Deposits.

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of the district plains is being gradually raised by this means, indeed, probably to the extent of 10 or 20 feet a century or more. Of course I cannot speak exactly on this point, but the quantity of mud spread out everywhere is certainly very large. In this reference an account of some previous operations of this kind is given in Hunter's Statistical Account of the province, pages 300 and 301.

3. With regard to the second point, as to the cultivators constructing any such dams for their own benefit, I have been unable to collect much information on the subject, but it is certain that such a practice prevails only to a very limited extent, and that operations of the kind are very petty. Of course, the usual paddy *bunds* called here "*ails*," round paddy fields when above water are constructed to keep the water confined; and the opening and shutting of these little embankments, or banks, is a constant source of quarrels. The "*ails*" are from 3 inches to a foot high. There are no lands requiring artificial irrigation here. It appears that in parganas Jaysri, Sukhair, and Atuajan in subdivision Sunamganj the "*ails*" are bigger than usual, but they are washed away every flood.

Small dams are made in parts of the Habiganj subdivision to keep hill streams off dwelling-houses, but these are very petty affairs. In Hunter's Statistical Account, page 301, it is said that the practice of controlling water by dams for the purpose of procuring silt is quite common, but I cannot find any one who has personally seen anything of the kind; I have not myself. The Executive Engineer tells me that channels are sometimes cut by villagers from rivers with the express purpose of producing silting, but this is not common, and usually too successful. Water, if given an opening, may enlarge it beyond control. The small resources of agriculturists are not equal to any great operations in this country, or Sylhet might have become a second Holland, instead of being in the wild condition it is. I may mention that in the low-lying marshy parts the villages are all on artificially raised sites—regular mounds—some of considerable antiquity and others more recent, up till those only just completed. These mounds are raised up gradually by the villagers and dug from channels round.

No. 4866, dated Shillong, the 26th October 1893, Memo. by the Director, Department of Land Records and Agriculture, Assam.

Forwards copy of letter No. 2963, dated the 28th September 1893, from the Deputy Commissioner, Sibsagar, with a copy of the enclosure, forwarded to the Secretary to the Chief Commissioner of Assam, in continuation of the letter No. 4358, dated the 1st September 1893, for information.

From F. J. MONAHAN, Esq., I.C.S., *Deputy Commissioner of* **Sibsagar,** *to the Director, Department of Land Records and Agriculture, Assam,—No. 2963, dated Sibsagar, the 28th September 1893.*

With reference to your letter No. 4421, dated the 7th September 1893, asking for information about the bunds in this district, I have the honour to say that, as you are aware, the whole of this district is intersected with old embankments made by the former Rajas. In some of these the intention of preventing inundation is apparent, while others appear to have

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been rather intended as roads, and in others again both of these objects were doubtless combined.

2. I enclose copy of a Note by the Executive Engineer, Sibsagar Division, which gives a list of the enbankments in the district now maintained by the Local Boards or Public Works Department with the object of preventing inundation.

3. In addition to these, I may mention that in the Sadr Subdivision, the Sologuri Ali, for a portion of its length, about 6 miles above Langalamora ghat, acts as a protection against floods from the Desang river. Along the right bank of the Upper Desang runs the Mahmora Ali, which joins the Sologuri Ali where the latter bund leaves the bank of the river, nearly opposite Luckwah garden. The Mahmora Ali is entirely in jungle now, and I am not sure what its total length is, but it was evidently intended as a flood embankment. There is a proposal to open up a part of it as a road. The Executive Engineer mentions the Bor Ali and Dikhumukh road as running for 16 miles along the left bank of the Dikhu river from Nazira to Dikhumukh. Both of these roads were formerly known as the Borali, which is said by tradition to have been continued along the bank of the Brahmaputra as a flood embankment as far as Nigriting, but the portion between Dikhumukh and Nigriting is not now maintained, and is not, I think, traceable anywhere in the Sadr or Golaghat Subdivision. The Assistant Commissioner of Jorhat reports that in that subdivision the Borali is traceable, and acts as a flood embankment against the Brahmaputra to some extent. The Assam trunk road under its different names of Garhali, Seoni Ali, and Machkhowaghar, also acts as an embankment against the Brahmaputra floods from Numolighar to near Sibsagar. The Dhodarali runs as an embankment along the right bank of the Dhansiri river from Golaghat to Kumargaon, a distance of about 20 miles. There are also old embankments along the right bank of the Bhogdoi and the left bank of the Jhanzi river in Jorhat Sub-division, which have not been maintained in recent years. There are, however, grants for their repairs in the Local Board's budget for the current year. The practice of constructing dams or embankments to prevent erosion or fertilise land by causing a deposit of soil does not prevail among the agricultural classes in this district.

Note by MR. BOLINARAYAN BORAH, *Executive Engineer,* ***Sibsagar*** *Division, dated the 24th September 1893.*

The following are the chief river embankments intended to prevent inundation :—

1. *The Desang Bund*—In three sections—

Section I.—From Sologuri Ali to trunk road, length about 8 miles.
" II.—From trunk road to Dhai Ali, length 4 miles.
" III.—From Dhai Ali to near Desangmukh, length $5\frac{1}{2}$ miles.

The whole of this *bund* is on the left bank of the river. The first two sections are old embankments maintained by the Local Board. The third section was newly constructed by the Public Works Department in 1892-93, and is being maintained by that department.

2. *The Dehing Bund*—extending on the left bank of the Dehing river, from the trunk road to Dehingmukh. This is an old embankment. It exists only in parts, and has not been repaired by the Board or by the Public Works Department for many years. It has been proposed to

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reconstruct it this year through the Public Works Department (as a Provincial work), and there is a budget grant for it. An estimate has been already submitted to the Superintending Engineer for sanction. Length about 9 miles.

3. *The Dhai Ali*—extending from the Dikhu river at Sibsagar to Dehingmukh. This is an old road embankment. It checks the flood of the Brahmaputra and protects to some extent the country to the east of it. About 6 miles of this embankment are maintained by the Local Board, and the rest (9 miles), which is more or less unfinished or damaged, is not maintained. An estimate has been sent up this year for raising and completing this bank. Total length is 15 miles.

4. *The Darika Bund*—extending on the left bank of the Darika river from the trunk road to the Dhai Ali, is maintained by the Local Board. Length 2 miles.

5. *The Dikhu Bunds.*—There are several old road and river embankments along both banks of the Dikhu river. They are maintained partly by the Local Board and partly by the Public Works Department.

The *Kajira Ali* and the *Taxali* on the right bank and the *Borali*, the trunk road, and the Dikhumukh road on the left bank, are primary road embankments, which check the flood of the Dikhu river, and prevent inundation in the country beyond them. These roads do not, however, closely follow the banks of the river. There are secondary embankments along the banks, which protect the country between the river and the main embankments. These secondary embankments are not, however, continuous, and the only bit which is now maintained by the Board is about 4 miles in length on the right bank from Kumargaon to the 2nd mile, Nazira Ali. This protects the town of Sibsagar. There is also a small bit on the opposite bank from the Amgurighat to the Metekaghat, which is sometimes repaired by the Board. Total length 42 miles.

Primary embankments.	Borali .	8 miles,	maintained by Board.
	Trunk road .	4 ditto	ditto by Public Works Department.
	Dekhumukh .	8 ditto	ditto ditto.
	Nazirali .	9 ditto	ditto by Board.
	Taxali .	7 ditto	ditto by Public Works Department.
Secondary embankments.	On right bank	4 miles	ditto by Board.
	On left „ .	2 „	

Besides these main embankments, there are old secondary embankments along other rivers, which are, however, not maintained.

BERAR.

IX.—BERAR (HYDERABAD).

From O. V. Bosanquet, Esq., *Secretary for Berar to the Resident at Hyderabad, to the Secretary to the Government of India,—No. 286, dated Hyderabad Residency, the 25th September 1893.*

Submits copy of a report prepared by the Director of Land Records and Agriculture, Hyderabad Assigned Districts, regarding the construction during recent years in that Province of dams or bunds for purposes other than that of irrigation.

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BERAR.

Letter No. 1700, dated Akola, the 30th August 1893, from F. W. Francis, Esq., Director of Land Records and Agriculture, Hyderabad Assigned Districts.

With reference to your endorsement No. 6498 of 20th July, to the Secretary for Berar's No. 2298, dated 14th July 1893, giving cover to Government of India's Circular $\frac{\text{Revenue and Agricultural Dept.}}{\text{Agriculture}}$ No. 23—113, dated Simla, 21st June 1893, I have the honour to state that—

(*a*) No action has been taken in recent years by the Berar Administration to promote the construction of dams or bunds for any purpose other than that of irrigation.

(*b*) The practice does prevail to a considerable extent among the agricultural classes of constructing dams for the prevention of erosion by drainage.

2. The Deputy Commissioner, Basim, reports that latterly there has been a large demand for *takavi* loans for this object.

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G. I. C. P. O. No.—76 R. & A. D.—17-6-97.—2,200

(Medical and Chemical Series, No. 9.)

THE

AGRICULTURAL LEDGER.

1897—No. 3.

SACCHARUM.

(SUGAR-CANE AND RAW SUGAR.)

[*Dictionary of Economic Products, Vol. VI., Pt. II.*,
(*Chemistry of Cane and Cane-Sugar*), S. 61-64.]

CHEMICAL COMPOSITION OF SUGAR-CANE AND RAW SUGARS.

Note (being the third) by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

Objects of the Experiments.—The principal objects of the experiments on sugar-cane, which are being carried out at the Experimental Farms at Poona, Cawnpur, Dumraon and Burdwan, were briefly detailed in the first paragraph of my second Note on the Composition of Sugar-cane and Raw Sugars (*vide The Agricultural Ledger No. 19 of 1896*). They are (1) to determine what quantity of manure may be most economically applied to this crop, and (2) what varieties are the best sugar-producers. For the results of the field experiments reference must be made to the Annual Reports of the Farms concerned.

2. The investigations into the chemical composition of the sugar-cane and its products, which I commenced in the cold weather of 1894-95 and continued in that of 1895-96, have again occupied my attention during the past season.

3. Of the several subjects mentioned in paragraph 2 of *The Agricultural Ledger No. 19 of 1896*, some I considered did not call for further attention at present.

EXPERIMENTS with SUGAR-CANE.

The amounts of Nitrogen and Phosphoric Acid, which are remove[d] by the crop, must naturally vary according to the weight of cro[p] and consequently the approximate estimate given on page 20, State[-]ment No. 14, *l. c.*, will be sufficient for the purpose of giving a[n] idea of the the total amounts of these plant foods removed in thi[s] crop.

Again, the amount of sugar which is removed in the scum during the boiling down of the juice, is a matter which I have not further enquired into, because, in the first place, it is impossible under the conditions in which the cultivator works to avoid taking sugar with the scum, and, secondly, this sugar is not wasted, but is put to one or other useful purpose.

Scum should be removed quickly.

Regarding this matter, however, I may here point to the desirability of taking off the scum as *quickly as possible*. It will be clear that the longer the scum remains floating on the pan of boiling juice, the more concentrated the juice becomes, and since approximately the same amount of liquid will be carried with the scum whenever it is removed, that liquid will contain more sugar if the juice has been allowed to concentrate first, than if the scum be removed whilst the juice is still dilute. The scum rises rapidly as soon as the liquid boils, and the skimming should be performed quickly and thoroughly at once. Then a small quantity of milk (about 4 ounces) may be advantageously added, which will cause a little more scum to form and this should again be got rid of as soon as may be.

The other subjects mentioned, *l. c.*, have again formed the subject of experiment.

Another class of experiments.

In addition, however, to the experiments which have been conducted on canes grown at the Farms, a considerable number of experiments have been made on cane grown by cultivators. The investigations of previous years had shown that it was most important to determine, as far as possible, two items in relation to the different varieties commonly grown, one being the amount of juice obtainable, and the other the percentage of sugar in the juice. A further matter engaged my attention, namely, the identification of varieties. The cultivators know their own varieties perfectly well and have names for them, but unfortunately these names are frequently of no service at all in finding out in two different districts whether one is dealing with the same or different

Importance of being able to identify varieties.

varieties. Consequently it seemed desirable to decide on a system of describing varieties, their appearance, etc., so that a variety grown, say, in places far apart might be identified by different observers.

EXPERIMENTS with SUGAR-CANE.

The descriptions of the varieties met with will be submitted in a separate paper, together with such information as has been collected relative to the percentage of juice and its quality.

'Laid' Cane. Effect on the Juice.

Another matter on which some additional information was obtained this season was the effect produced on the juice by the cane being "laid". In the case of the crop of "Matna" variety grown at Cawnpur in 1894-95, a good deal of the crop was laid by excessive rain, and it was then found that the juice of such cane contained less sugar than that of the standing cane.

The crop of 1895-96 was not "laid" at all, but this year, owing to the height to which many of the varieties grew, a good deal fell down, and the fallen cane was crushed separately and its juice analysed.

Juice from top end and main portion of cane compared.

A third subject of investigation was the comparative quantity and quality of the juice of the top end and that of the main portion of the canes. In the Burdwan district the crops are usually grown exclusively from the "tops" of canes, whilst in most other parts the whole cane is cut up for seed. As will be seen from paragraph 8, the Burdwan practice is an economical one.

Density of Juice in regard to amount of Sugar.

A further subject on which I have been engaged is the relationship between the specific gravity or density of the juice and the percentage of total sugar. Information on this point will be of service to those who may wish to know the amount of sugar in juice, but who have not the means at hand to determine it chemically.

Topics considered in the present paper.

The subject matter of the present Note may accordingly be conveniently dealt with under the following heads:—

(*a*) The amounts of cane-sugar and glucose in sugar-cane juice.

(*b*) The relative composition of the top end and the main portion of the cane.

(*c*) The relation between the specific gravity of juice and the percentage of total sugar.

(*d*) The amount of cane sugar and Glucose in *Rab*.

(*e*) The amount of "inversion" during the boiling process and the effect of liming.

E-SUGAR GLUCOSE HE JUICE.

(*f*) Handcentrifugal-made sugar.

4. (*a*) ***The amounts of cane-sugar and of glucose in sugar-cane juice.***—The quality of the juice may be again conveniently dealt with under three heads (*l. c.*, page 2) namely:—

(1) the comparative quality of the juice of different varieties grown at the same place;

(2) the effect on the quality of the juice of transferring cane to long distances;

(3) the comparative quality of the juice of the same variety grown with different amounts of manure;

rieties. wnpur.

5. ***The amounts of cane-sugar and glucose in the juice of varieties grown at the same place. Cawnpur.***—At this farm the same six varieties were again cultivated as in 1895-96 and Statement No. 1 exhibits the results.

ing of eaves. rdwan ethod.

Each variety was grown on two plots, all of which were manured with Poudrette, the one set of plots receiving about 250℔ of Nitrogen per acre in the manure, the other set about 500℔ of Nitrogen. Although the cultivation was very good indeed, the crops grew so tall that they fell down considerably. An attempt was made to tie them up with the dry leaves, a method commonly practised in the Burdwan district, but the attempt was not altogether effective. This method of keeping the crop erect is very successful if properly carried out, but no one at Cawnpur had seen it done, and it is probable that the tying up commenced too late. At Burdwan tying commences when the crop is only a couple of feet high. It is necessary to mention this because cane, even when 14 and 16 feet high, will remain erect if properly supported in this manner.

uice of ding and d ' cane npared.

Statement No. 1 exhibits the analyses of the juice of the six varieties as grown, each on two plots; one analysis being for the juice of the cane which remained erect, the other for the juice of the cane which fell. There is some difference between the amounts of sugar in the juice of the standing and fallen cane respectively in each case, the juice of the fallen cane containing a somewhat lower proportion of sugar. The loss is not, however, so great as it was in the case of the crop of "Matna" in 1894-95, which was laid by rain (*vide* page 3, *Agricultural Ledger No. 13 of 1895*).

EXPERIMENTS with SUGAR-CANE. Cawnpur.

STATEMENT NO. 1.

Composition of Juice of Varieties, Cawnpur, 1896-97.

VARIETY.	MANURED WITH POUDRETTE = 500lb NITROGEN PER ACRE.											
	MADRASI.		SAHARANPURI.		POONA.		DEKCHAN.		DHAUL.		MATNA.	
Quality of Cane.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.
Cane sugar	11·39	12·63	13·54	10·55	12·26	14·52	10·99	7·81	13·32	12·27	13·36	11·17
Glucose	1·44	·89	·67	2·25	·82	·67	·49	·96	·57	·66	·77	1·17
TOTAL SUGAR .	12·83	13·52	14·21	12·80	13·08	15·19	11·48	8·77	13·89	12·93	14·13	12·34
Ratio : Total Sugar to Glucose .	11·28	6·58	4·72	17·58	6·27	4·41	4·27	10·95	4·10	5·10	5·45	9·48

VARIETY.	MANURED WITH POUDRETTE = 250lb NITROGEN PER ACRE.											
	MADRASI.		SAHARANPURI.		POONA.		DEKCHAN.		DHAUL.		MATNA.	
Quality of Cane.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.	Standing.	Fallen.
Cane sugar	13·50	11·80	14·92	13·80	12·52	10·92	6·93	6·29	11·48	10·30	8·97	8·54
Glucose	·94	1·56	·37	·54	1·14	1·57	1·71	1·78	1·35	1·12	1·19	1·54
TOTAL SUGAR .	14·44	13·36	15·29	14·34	13·66	12·49	8·64	8·07	12·83	11·42	10·16	10·08
Ratio : Total Sugar to Glucose .	6·51	11·67	2·42	3·76	8·34	12·57	19·79	22·05	10·52	9·80	11·71	15·3

PERIMENTS with R-CANE.

Generally it may be said that the percentage of sugar is much the same in each of these varieties as last year, with the exception of the "Matna", and the change which appears to have occurred in this case will be the subject of remark in a later paragraph.

nraon.

Dumraon.—At the Dumraon Farm the same six varieties were again grown as in 1895-96 but with somewhat different manures. In 1896-97 each variety was grown on two plots, one being manured with castor-cake containing 250℔ Nitrogen per acre, the other receiving cattle-dung containing 250℔ Nitrogen per acre. At this farm the water-supply broke down altogether after the monsoon ceased and the crops, especially the "Poona" and "Red Bombay," simply dried up to a large extent and were attacked by white ants.

At Dumraon the tying up was done well by a man from Burdwan, otherwise it is probable that all the large cane would have fallen. Before crushing the dried cane was separated as completely as possible from the sound cane and the analyses in Statement No. 2 are those of the latter only.

It will be seen that usually the amount of sugar in the juice of the cane from plots manured with castor-cake was poorer than in that from the plots manured with cattle-dung. This is likewise a point which will be referred to in a subsequent paragraph (No. 7). This circumstance occurred in five cases out of the six.

Generally the amount of sugar in the juice of these varieties is somewhat greater than in the crops of 1895-96, the increase being in cane-sugar, whilst the proportion of glucose has decreased in several instances.

dwan.

Burdwan.—This is the first occasion on which analyses of varieties of sugar-cane have been made at this farm. Only two varieties were grown there, and the composition of the juice is exhibited in the following statement:—(No. 3).

EXPERIMENTS with SUGAR-CANE.
Dumraon.

STATEMENT NO. 2.

Composition of Juice and Gur of Varieties, Dumraon, 1897.

VARIETY.	MUNGO.		BHURLI.		SAMSARA.		RED BOMBAY.		POONA.		KHARI.	
Treatment. Manure = 250lb Nitrogen per acre.	Castor-cake.	Cattle-dung.	Castor-cake.	Cattle-dung.	Castor-cake.	Cattle-dung.	Castor-cake.	Cattle-dung.	Castor-cake.	Cattle-dung.	Castor-cake.	Cattle-dung.
Cane-sugar	11·73	13·53	13·76	16·09	12·35	15·36	13·31	14·33	12·77	12·35	10·90	15·43
Glucose	1·18	·46	·70	·23	1·34	·72	1·00	·85	·81	1·31	·71	·32
TOTAL SUGAR .	12·91	13·99	14·46	16·32	13·69	16·08	14·31	15·18	13·58	13·66	11·61	15·75
Ratio: Total Sugar to Glucose .	9·14	3·29	4·84	1·40	9·79	4·48	6·99	5·66	5·96	9·59	6·11	2·03

S. 61-64.

EXPERIMENTS with SUGAR-CANE. Burdwan.

STATEMENT No. 3.

Analyses of the Juice of varieties grown at the Burdwan Farm.

VARIETY.	SAMSARA.	KHARI.
Manure applied.	Cattle-dung N.=250 lb per acre.	Cattle-dung N.=250 lb per acre.
Cane-sugar	14·78	16·59
Glucose	1·33	1·03
TOTAL SUGAR . .	16·11	17·62
Ratio: Total Sugar to Glucose . . .	8·25	5·84

The "Samsara" cane was grown on a second plot manured with castor-cake, the juice of this plot having the same specific gravity as that analysed.

Cane transported to long distance. Effect on the Juice.

6. ***The effect on the juice of transporting cane to long distances.***—At the time of writing my last Report on this subject, there were only two cases which could be quoted in evidence of the effects produced on cane by transport to long distances.

Mauritius cane.

The one was the case of the two varieties of Mauritius cane, imported in 1894. These two varieties were supposed to be very rich in sugar when they were first obtained, and it was surprising to find that both in the crop of 1894-95 as likewise in that of 1895-96 the juice contained comparatively little sugar. They were grown again in 1896-97 at Poona, and it is satisfactory to find that in both cases the percentage of sugar has risen. The "white Mauritius" which contained about 12 per cent. cane-sugar and 1·4 glucose in 1895, produced a juice containing 14·71 per cent. cane-sugar and ·99 per cent. glucose in the past year's crop, while the "Red Mauritius," which had only about 10 per cent. cane-sugar and 2 per cent. glucose in the juice of the crop of 1895-96, had 12·7 per cent. cane-sugar and 1·5 per cent.

glucose in the past year's crop. Thus in both cases there has been a very material improvement.

EXPERIMENTS with SUGAR-CANE.

The second case quoted in my previous Note was that of the "Poona Pundia" variety which had been grown in 1895-96 at Cawnpur and Dumraon. It was then found that, instead of containing about 16 to 18 per cent. of total sugar as at Poona, the crops at these farms contained only about 14 per cent. of total sugars (*l. c.*, page 3). The same variety was again grown at the two farms last year, and as will be seen from a comparison of the quality of the juice of the "Poona" variety as exhibited in Statements Nos. 1 and 2 of Agricultural Ledger No. 19 of 1896 with the corresponding figures in Statements Nos. 1 and 2 of this Note, the percentage of sugar remains about the same and no improvement has yet taken place.

Poona cane grown at Cawnpur and Dumraon.

Some further evidence on this point was obtained during the past season. A number of varieties of cane commonly grown in the Bombay Presidency were collected at the close of 1895 and planted at Poona. These were all analysed during the past cold weather. Later I visited villages in the neighbourhood of Belgaum and Dharwar, and analysed some of these same varieties as grown by the cultivators, and the results may here be quoted.

Bombay cane grown at Poona.

It will be seen from the figures in Statement No. 4 that in three cases the quality of the juice was much lower in the crop at Poona than at the place from which the cane was obtained, in two instances it was higher and in one the quality remained stationary.

Using of different manures. Effect on the Juice.

7. ***The juice of the same variety grown with different manures.***—When reporting last year on the effect which manuring has on the quality of sugar-cane, I cited two cases in neither of which had the manuring caused any change. The natural conclusion was therefore drawn that manuring had no effect on the quality of cane. The one was the "Poona Pundia" grown at Poona and the other was "Matna" variety grown at Cawnpur. This year another variety the "Madrasi Pounda", a large cane extensively grown in the North-Western Provinces and Oudh was grown at Cawnpur with varying amounts of manure and the composition of the juice is set out in Statement No. 5. In this case likewise the manuring, neither in amount nor kind, has produced any effect on the quality of the juice, and I may also add that the percentage of juice expressible in the mill was also apparently unaffected.

EXPERIMENTS with SUGAR-CANE.
Bombay.

STATEMENT NO. 4.

Showing the amount of Sugar in the Juice of Varieties grown at certain places in the Bombay Presidency, 1897.

Variety.	Where grown.	Per cent. Cane-sugar.	Per cent. Glucose.	Where grown.	Per cent. Cane-sugar.	Per cent. Glucose.
Pundia .	Khanapur .	16·50	·85	Poona .	12·60	1·48
Sana Bli Kabbu .	Do. .	13·31	1·09	Do. .	17·38	·68
Kari Kabbu	Belgaum .	11·47	1·67	Do. .	11·67	1·54
Do. .	Khanapur .	16·67	1·11	Do. .	6·13	2·57
Betta Kabbu	Belgaum .	13·2	·77	Do. .	9·10	1·19
Hulbi Kabbu.	Do. .	14·68	·43	Do. .	16·06	Very little.

The "Poona Pundia" is one of the largest varieties grown in India, it is extensively cultivated in the Deccan and Southern Mahratta country, and is generally, if not always, manured heavily. It was also grown with large amounts of manure at the Poona Farm.

The "Matna" is a small thin cane extensively grown in some parts of the North-Western Provinces and Oudh and is usually manured but little. At the Cawnpur Farm in 1894-95 and 1895-96 it was grown with comparatively small quantities of manure.

It thus so happened that in each case the particular variety on which the evidence of the effect of manuring rested, was manured in much the same manner as the plants were accustomed to. The case of the "Madrasi" crop above referred to would likewise afford evidence that manuring has no effect on the juice.

The crop of "Poona Pundia" grown at Poona in 1896-97 was not analysed this year. There seemed to be no object in repeating the experiment, since the quality of its juice had remained constant for two years (*vide Agricultural Ledgers Nos. 13 of 1895*, page 2, and *19 of 1896*, page 5).

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EXPERIMENTS with SUGAR-CANE. Cawnpur.

STATEMENT NO. 5.

Cawnpur Sugar-cane Experiments, 1896-97, Madras Paunda-Manure Series.

Plot.	Plot 2. Dung=250lb N.	Plot 3. Dung=500lb N.	Plot 4. Poudrette=250 lb N.	Plot 5. Poudrette=500 lb N.	Plot 6. No Manure.	Plot 7. Bone meal=125lb Saltpetre=125lb.	Plot 8. Castor-cake=250lb N.
Quality of Cane	I	I	I	I	I	I	I
Per cent. Cane-sugar	15·35	14·85	14·37	14·58	15·62	14·54	13·96
Do. Glucose	·78	·79	·93	·67	·49	·49	·92
TOTAL SUGAR	16·13	15·64	15·30	15·25	16·11	15·03	14·88
Ratio: Glucose per 100 of Total Sugar	4·95	5·05	6·08	4·39	3·04	3·26	6·18

EXPERIMENTS with SUGAR-CANE.

Cawnpur.

The "Matna" variety was grown at Cawnpur in 1896-97 on two plots, both of which had a dressing of Poudrette, in one case containing Nitrogen equal to 500lb per acre, and in the other Nitrogen equal to 250lb per acre, both amounts of manure being far more than is usually given to this variety. The crop grew about twice as high as usual. But in this case manuring seems to have had a material effect upon the cane. In 1894-95 this variety, grown with small amounts of manure, yielded on an average of 9 plots 51 per cent. of juice at the mills; in 1895-96, when it was again grown with small amounts of manure on 9 plots, the percentage of juice extracted was 46·5; in 1896-97, when it was *grown with large amounts of manure*, the proportion of juice obtained was 60·3 per cent. On the other hand, the percentage of cane-sugar in the juice of these crops was 14·9, 16·2, 11·2 for the corresponding years, and of glucose 0·4 and 1·0 per cent. in the last two years. Thus, whilst the percentage of juice has increased very considerably with the increased supply of manure, the proportion of sugar has fallen very seriously.

At the same time, although this result must be attributed to the heavy manuring, it would not be at all proper to infer that heavy manuring is to be deprecated generally. It is really a case of having grown a certain variety of cane under essentially different conditions to those to which it is usually accustomed.

Another instance of a similar nature may be quoted. The Bhurli and Mungo varieties of Behar have been grown for two years at Dumraon with large amounts of manure (*vide Agricultural Ledger No. 19 of 1896*, page 2, and Statement No. 2 of this paper). The percentage of total sugar in the Juice of the Mungo variety in 1896 was 10·5, in 1897, 13·0 and 14·0 (two plots). The percentage of sugar in that of Bhurli was 13·6 in 1896, and 14·5 and 16·3 in 1897. At Behea I happened to analyse a sample of the mixed juice of these two varieties (they are commonly grown there as a mixed crop with little or no manure). The juice expressed came to 53 per cent.; it contained 17·9 per cent. of cane-sugar and ·23 of glucose, an amount much in excess of that found at Dumraon, and one may infer that the heavy manuring at Dumraon has reduced the percentage of sugar. The instance is parallel to that of the Matna variety at Cawnpur; in each case, varieties have been grown under essentially different conditions to those to which they are

accustomed, and this appears to have had a disturbing effect on the juice.

EXPERIMENTS with SUGAR-CANE.

We have, therefore, evidence not only that cane may suffer from a change of climate, but also that, if other conditions, such as manuring, are materially changed from those under which the plant has been long cultivated, the quality of the juice may be lowered.

When presenting this evidence of the (possibly) bad effect produced on certain varieties of cane by heavy manuring, it must not be assumed that such effect is permanent. On the contrary, judging by the Bhurli and Mungo varieties grown at Dumraon, one may expect that the normal proportion of sugar will again be obtained in the course of a year or two.

Moreover, and this is a still more important factor, with an increased supply of manure a much heavier crop is obtained, far outbalancing such depreciating effects on the juice as have been quoted.

Quality of different parts of the cane compared.

Burdwan.

8. ***(b) The relative composition of the top end and the main portion of the cane.***—As already explained in paragraph 3, it is of interest to know the comparative quality of different parts of the cane, because in some places, such as Burdwan district, Bengal, it is the practice to grow the crop exclusively from sets cut from the top end of canes, whilst in most parts of India the whole cane is cut up for planting.

I therefore made five experiments at Burdwan in which a bundle of whole cane was taken in each case, the tops cut off and the two portions weighed. They were then passed through the mill separately, and the juice analysed in three cases, the specific gravity alone being determined in the other two.

The results of these experiments are set out in Statement No. 6, in the upper part of which is given the weight of cane operated upon and the percentage of juice obtained, whilst in the lower part is furnished the analysis of the juice.

In the first place it will be noticed that the amount of Juice obtainable from the top end of cane is very much less than that from the main portion of the stem, the percentage in the former case varying between 46·6 and 56·1, whilst in the latter it was between 61 and 74·1.

EXPERIMENTS with SUGAR-CANE.

Burdwan.

STATEMENT No. 6.

Showing the Comparative Composition of the top and main portions of Sugar-cane, Burdwan, 1897.

Variety.	Samsara Cattle-dung Plot.		Samsara Cattle-dung Plot.		Samsara Castor-cake Plot.		Samsara Castor-cake Plot.		Khari Cattle-dung Plot.	
	Main part of cane.	Tops.	Main part of cane.	Tops.	Main part of cane.	Tops.	Main part of cane.	Tops.	Main part of cane.	Tops.
	℔ oz.	℔ oz.	℔ oz	℔ oz.	℔ oz.	℔ oz.	℔ oz.	℔ oz.	℔ oz.	℔ oz.
Weight of Cane or tops .	47 0	4 2	38 8	3 4	20 8	2 14	43 8	5 2	19 0	2 6
" Juice . . .	34 8	2 2	23 8	1 8	14 0	1 8	32 4	2 14	11 12	1 2
Percentage of Juice . .	73·4	51·5	61·0	46·6	68·2	52·1	74·1	56·1	61·8	47·3
Mean weight of Canes or tops	3·9	·23	...	...	...	...	3·6	·33	1·2	·11
Specific gravity at 15·5° C. .	1073	1050	1078	1066	1082	1069	1081	1064	1084	1071
Composition of Juice. Cane-sugar .	14·65	7·06	approximately	approximately	approximately	approximately	17·17	11·50	18·96	13·44
Composition of Juice. Glucose .	1·66	2·51	equal to	equal to	equal to	equal to	1·08	1·38	·36	1·14
Total Sugar .	16·31	9·57	17·0	13·5	18·0	14·5	18·25	12·88	19·32	14·58
Ratio: Total Sugar to Glucose	10·18	26·12	...	...	...	...	5·92	10·71	1 86	7·82

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EXPERIMENTS with SUGAR-CANE. Burdwan.

Then, secondly, it will be seen that the amount of cane-sugar and of total sugar is much higher in the juice of the main part of the stem than in that of the top, but the amount of glucose is much lower in the former than in the latter.

That this is not in any way exceptional to the canes grown at Burdwan will be evident from an inspection of the analyses detailed in Statement No. 7.

STATEMENT. NO. 7.

Composition of Juice of different parts of Sugar-cane. Poona, 1895.

	MEDIUM-SIZED CANE.	LARGE CANE.	SMALL CANE.	SMALL CANE.
	Per cent. Cane-sugar.	Per cent. Cane-sugar.	Per cent. Cane-sugar.	Per cent. Cane-sugar.
Top end . . .	15·38	10·41	12·24	12·08
Middle . . .	20·21	18·67	17·76	17·46
Bottom end . . .	18·05	19·95	19·13	19·28

When at Poona in 1895 I determined the percentage of cane-sugar in different parts of four sample canes of the "Poona Pundia". In this case the analyses are of the juice of single canes, but the evidence is quite uniform, and confirms that obtained this year at Burdwan.

Assuming that just as good a crop will be obtained from planting with the tops only, instead of cutting up the whole cane, and further that cane will not deteriorate from being thus propagated, it will be evident that it is much more economical to grow from tops only. It is difficult to estimate the gain from the adoption of the Burdwan custom, but the following calculation based on the figures quoted in Statement No. 6 will perhaps exemplify the difference. Assuming that 12,000 "sets" of Samsara variety are planted per acre and that each "set" from the main part of the cane weighs 35lb then the weight of cane required for sowing one acre would be 4,200lb. If this were crushed for sugar production, the weight of *gur* obtainable may be calculated thus: it may be assumed that it will be possible to extract 70 per cent. of juice; that the percentage

EXPERIMENTS with SUGAR-CANE.

Burdwan.

of total sugar will be 17, that 10 per cent. of the total sugar would be taken off with the scum, and that the *gur* would contain about 80 per cent. of total sugar. Then from the 4,200lb of cane, 2,940lb of juice would be obtained; containing 500lb of pure sugar; deduct 10 per cent. lost in the scum and the remaining 450lb of pure sugar would produce about 560lb of *gur*.

On the other hand, the amount of *gur* obtainable from 12,000 top ends of canes may be calculated thus: Each set will weigh say, ·28lb (*vide* Statement No. 6), and the weight of cane planted would thus be 3,360lb. If crushed, this cane would yield, say, 50 per cent. of juice containing 12·5 per cent. of total sugar. Thus from the 3,360lb of cane, 1,680lb of juice would be obtained containing 210lb of pure sugar. Deduct 10 per cent. lost in the scum or 21lb and the remaining 189lb would give about 236lbs. of *gur*.

Thus assuming that this case fairly illustrates the different amounts of *gur* obtainable from the top ends and the main portion of the "Samsara" variety, planting the whole cane means a loss of some 320lb of *gur* per acre planted.

A similar calculation for the other variety, namely, Khari, which was experimented upon, shows a loss of about 140lb of *gur* by planting from the main part of the cane. This variety is a thin one and the "sets" weigh consequently much less than do those of the thick "Samsara" cane.

In any case the subject is worthy of experiment, and some cane will be grown from the top ends and main portions of cane at one or two of the farms.

The evidence at hand certainly does not indicate that cane depreciates from being continuously propagated from the top ends. The "Samsara" cane at Burdwan is an exceptionally good variety, yielding about 70 per cent. of juice at the mills and some 15 to 18 per cent. of total sugar in the juice, and apparently the method has been in vogue for a long time there.

Specific gravity of juice and percentage of total sugar.

9. ***The relation between the specific gravity of juice and the percentage of total sugar.***—The value of a cane may be said to depend in a great measure on the percentage of juice obtainable from it and the percentage of sugar in that juice.

The former may be readily determined by crushing 80 or 100lb of any particular variety and weighing the juice expressed. Iron

EXPERIMENTS with SUGAR-CANE.

Specific gravity of juice and percentage of total sugar.

mills are to be had almost anywhere now and the operation can be carried out by any one who possesses a good spring balance. The percentage of sugars in the juice can only be accurately determined by means of certain chemical operations, for the performance of which a special training is necessary. In the case of pure, or nearly pure, solutions of sugars the specific gravity bears a definite relation to the percentage of sugar, and they may in such cases be determined with a fair degree of accuracy by observing the specific gravity of the solution together with the temperature prevailing at the time. This is an operation which any careful person may perform. In the case of cane juice, however, other substances are present which also influence the density, and the same relation between specific gravity and percentage of sugar no longer holds good. It occurred to me, however, that the proportion of these other substances might be tolerably permanent in cane juices generally, and in that case tables might easily be prepared showing the percentage of total sugars which corresponds to the specific gravity.

A considerable number of samples of juice of different varieties of cane have now been examined chemically and the percentage of cane-sugar and glucose determined in them. I have, therefore, put these together in Statement No. 8, in which is also entered the specific gravity of the juice at 15·5° C and the percentage of sugar which corresponds to the specific gravity in each case, *on the assumption that the density is entirely due to sugar.*

See pp. 18 and 21.

Owing to the presence of the other substances referred to, this calculated proportion of sugar will always be too high and it was with the object of finding out whether the difference between the calculated and true percentage of sugar remained fairly constant that the comparison was made. There is no ready means of determining the amounts of these other substances (consisting as they do of albuminous matters, carbohydrates other than sugar, organic acids, etc.), and in such cases a simple method is to make a large number of determinations of the one factor (in this case sugar) and see if the other material or "difference" remains fairly constant.

In the last column of the statement is entered the difference between the calculated and true amount of sugar in each sample of juice examined.

SACCHARUM. Chemical Composition of

EXPERIMENTS with SUGAR-CANE.

Statement No. 8

Showing the specific gravity of juices at 15·5° C. with calculated per cent. total sugar and per cent. total sugar found.

Samples.	Specific gravity at 15·5° C.	Per cent. Total sugar from specific gravity.	Per cent. Total sugar found.	Difference.
South Mahratta Sugar canes.				
Karé Kabbu, Khanapur	1,087	21	17·8	3·2
Pundia, Khanapur	1,080	19½	17·4	2·1
Striped cane, Khanapur	1,085	20½	18·0	2·5
Sana Blé, Khanapur	1,082	20	18·0	2·0
Hullu Kabbu, Santa Bastwad	1,083	20	17·0	3·0
Pundia Santi, Bastwad	1,090	21½	18·7	2·8
Rasala, Belgaum	1,073	18	15·9	2·1
Pundia-Kilgiri, Dharwar (flowered)	1,082	20	18·3	1·7
Do. do. (not flowered)	1,083	20	17·9	2·1
Striped cane, Kilgiri	1,078	19	17·3	1·7
Hullu Kabbu, Aluawar	1,084	20	18·1	1·9
Pundia, Narendra	1,080	19½	17·2	2·3
Do. do.	1,078	19	17·1	1·9
Karé Kabbu, Narendra	1,076	18½	16·2	2·3
Do. do.	1,072	17½	15·1	2·4
Striped cane, Maungatti	1,087	21	18·1	2·9
Do. do.	1,078	19	16·6	2·4
Ratooned Pundia, Manjri . Plot iii	1,074	18	15·91	2·1
Red Mauritius cane, Manjri	1,065	16	15·2	·8
Ratooned Pundia, Manjri . Plot (cotton seed)	1,065	16	16·0	...

STATEMENT NO. 8

Showing the specific gravity of juices at 15·5° C. with calculated per cent. total sugar and per cent. total sugar found—contd.

SAMPLES.	Specific gravity at 15·5° C.	Total sugar calculated from specific gravity.	Total sugar determined.	Difference.
Cawnpur Farm.				
Madrasi Pounda . . Plot 2 .	1,073	18	16·1	1·9
Do. do. . . " .	1,073	18	16·2	1·8
Do. do. . . Plot 3 .	1,072	17·5	15·6	1·9
Do. do. . . " .	1,067	16·5	14·1	2·4
Do. do. . . Plot 4 .	1,071	17	15·3	1·7
Do. do. . . " .	1,065	16	13·9	2·1
Do. do. . . Plot 5 .	1,070	17	15·3	1·7
Do. do. . . " .	1,067	16·5	13·8	2·7
Do. do. . . Plot 6 .	1,073	18·0	16·1	1·9
Do. do. . . " .	1,070	17	14·9	2·1
Do. do. . . Plot 7 .	1,071	17	15·0	2·0
Do. do. . . " .	1,067	16·5	14·0	2·5
Do. do. . . Plot 8 .	1,068	16·5	14·9	1·6
Do. do. . . " .	1,068	16·5	15·0	1·5
Do. do. . . Field A. B.	1,064	16	12·8	3·2
Do. do. . . "	1,066	16	13·5	2·5
Saharanpuri do. . . "	1,066	16	14·2	1·8
Do. do. . . "	1,062	15	12·8	2·2
Poona do. . . "	1,063	15·5	13·1	2·4
Do. do. . . "	1,071	17	15·2	1·8
Dikchan do. . . . "	1,060	15	11·5	3·5

SACCHARUM. Chemical Composition of

EXPERIMENTS with SUGAR-CANE.

STATEMENT NO. 8

Showing the specific gravity of juices at 15·5° C. with calculated per cent. total sugar and per cent. total sugar found—contd.

Samples.		Specific gravity at 15·5° C.	Total sugar calculated from specific gravity.	Total sugar determined.	Difference.
Cawnpur Farm—contd.					
Dikchan Pounda . . .	Field A. B.	1,044	11	8·8	2·2
Dhaul do. . . .	„	1,066	16	13·9	2·1
Do. do. . . .	„	1,062	15	12·9	2·1
Matna do. . . .	„	1,067	16·5	14·1	2·4
Do. do. . . .	„	1,062	15	12·3	2·7
Saharanpuri Pounda . .	Field 10-11	1,070	17	15·3	1·7
Do. do. . . .	„	1,069	17	14·3	2·7
Madrāsi do . . .	„	1,067	16·5	14·4	2·1
Do. do . . .	„	1,066	16	13·4	2·6
Poona Pounda, Field 10-11	Fallen cane .	1,059	14·5	12·5	2·0
Do. do. „	Standing cane	1,062	15	13·6	1·4
Dikchan do. „	„	1,044	11	8·6	2·4
Do. do. „	Fallen . .	1,039	10	8·1	1·9
Dhaul do.	Standing .	1,062	15	12·8	2·2
Do. do.	Fallen . .	1,058	14	11·4	2·6
Matna do.	Standing .	1,049	12	10·1	1·9
Do. do.	Fallen . .	1,049	12	10·1	1·9
Varieties at Dumraon Farm.					
Mungo, castor-cake	Plot	1,058	14·0	12·9	1·1
Do. cattle-dung	„	1,064	16·0	14·0	2·0

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EXPERIMENTS with SUGAR-CANE.

STATEMENT No. 8

Showing the specific gravity of juices at 15·5° C. with calculated per cent. total sugar and per cent. total sugar found—concld.

SAMPLES.		Specific gravity at 15·5° C.	Total sugar calculated from specific gravity.	Total sugar determined.	Difference.
Varieties at Dumraon Farm—contd.					
Bhurli, castor-cake	Plot	1,067	16·5	14·5	2·0
Do. cattle-dung	"	1,074	18	16·3	1·7
Red Banchay, castor-cake . . .	"	1,066	16	14·3	1·7
Do. cattle-dung . . .	"	1,067	16·5	15·2	1·3
Samsara, castor-cake . . .	"	1,067	16·5	13·7	2·8
Do. cattle-dung . . .	"	1,074	18·0	16·1	1·9
Khari, castor-cake	"	1,059	14·5	11·6	2·9
Do. cattle-dung	"	1,073	18·0	15·7	2·3
Poona, castor-cake	"	1,063	15·5	13·6	1·9
Do. cattle-dung	"	1,062	15·0	13·7	1·3
Varieties at Burdwan.					
Kajli (ryots)		1,081	19·5	18·6	·9
Samsara (ryots)		1,078	19·0	17·1	1·9
Do. (farm)		1,075	18·0	16·1	1·9
Khari (farm)		1,078	19·0	17·6	1·4
Varieties at Behea.					
Pansabi (Behea)		1,071	17·0	15·0	2·0
Mungo (Behea)		1,081	19·5	18·1	1·4

EXPERIMENTS with SUGAR-CANE.

It will be seen from this column that, although the "difference figure" is not by any means constant, yet it lies between moderately narrow limits.

See Statement No. 8, pp. 18-21.

Of the 76 samples analysed it is less than 1·7 in 11 cases, between 1·7 and 2·2 in 40 cases, between 2·2 and 2·7 in 17 cases, between 2·7 and 3·2 in 7 cases and over 3·2 per cent. in one case. Thus in 40 cases out of 76, the difference figure lay between 1·7 and 2·2, and in 17 other cases it lay between 2·2 and 2·7. If, therefore, 2·0 be deducted from the percentage of sugar as calculated from the density, the error would lie between comparatively narrow limits, and a very fairly accurate idea would be obtained of the amount of sugar present in the juice of any variety to be examined. Based on these considerations I give, as an appendix to this Note, tables from which first the observed density may be reduced to density at 60° F. and 84° F., and secondly the approximate percentage of total sugar which correspond to the specific gravity of juices.

Analysis of raw sugar, *gur*, or *gul*.

10. (*d*) ***The amount of Cane Sugar and Glucose in Rab.***— In *The Agricultural Ledger No. 19 of 1896* is given the composition of a number of samples of *gur* or *gul*. Some further analyses of this material were made this year; but this was done principally in connection with experiments in liming juice, and these will be referred to in the next paragraph. Another description of raw sugar is prepared in some localities, for instance, Behea and Burdwan. This consists of a semi-liquid mass obtained by stopping the boiling process a little sooner than is the case when hard *gur* is wanted. It is transferred from the boiling pan, whilst still hot, to an earthen *ghurra* or *nand*, and in this it is allowed to cool slowly, when a considerable proportion of the cane-sugar crystallises out. At Burdwan this substance goes by the name of *gur*, but at Behea it is called *rab*.

See p. 23.

The analyses of this material, which are quoted in the accompanying Statement No. 9, are interesting chiefly as showing its composition, and may be compared with analyses of hard *gur* published in my previous paper. In addition, four other samples of *rab* are detailed in Statement No. 12. For these "rabs" which were prepared at the Burdwan Farm, the analyses of the juice are also given. There is considerable variation in the composition of these samples, not only in the total amount of sugar but also in the proportion of glucose.

EXPERIMENTS with SUGAR-CANE.

Burdwan.

STATEMENT No. 9.

Analyses of Juice and Gur, Burdwan, 1897.

VARIETY.	KAJLI.	SAMSARA.	SAMSARA.	KHARI.	PURI.	...
Where grown.	Villages, Banpata, Hartsimal, Kantalgachi.	Villages, Banpata, Hartsimal, Kantalgachi.	Experimental Farm.	Experimental Farm.	Village.	Judgespore Behea.
Treatment (manure).	*(Average sample.)	*(Average sample.)	Castor-cake plot. Cattle-dung plot.	Cattle-dung.	...	...
Juice—						
Specific gravity at 15·5° C. .	1,080 : 1,083 : 1,080	1,079 : 1,078 : 1,078	1,075 : 1,075 :	1,078	1,083	...
Cane-sugar	17·05	15·24	14·78	16·59	18·02	...
Glucose	1·54	1·86	1·33	1·03	·76	...
TOTAL SUGAR .	18·59	17·10	16·11	17·62	18·78	...
Ratio : Total Sugar to Glucose .	8·28	10·88	8·25	5·84	4·04	...
Gur (*Rab*)—						
Cane-sugar	66·48	64·36	73·29	68·68	70·06	71·59
Glucose	7·70	19·01	13·25	7·53	4·56	4·38
TOTAL SUGAR .	74·18	83·37	86·54	76·21	74·62	75·97
Ratio : Total Sugar to Glucose .	10·38	22·80	15·31	9·88	6·11	5·76

* The specific gravity of these three samples of juice from the cane of three villages being so nearly equal, only one analysis was made. The juice was mixed and boiled down together.

S. 61-64.

EXPERIMENTS with SUGAR-CANE.

"Inversion" during boiling and effect of liming.

11. (*c*) ***The amount of "inversion" during the boiling process and the effect of liming.***—The experiments which were made last year to determine to what extent the formation of glucose could be prevented by the addition of lime to the juice showed that "inversion" could be stopped almost completely, but that in order to add the most desirable amount of lime, considerable care was required. Thus in *Agricultural Ledger No. 19 of 1896, p. 12,* Statement No. 9, it was shown that if about nine-tenths of the acidity in the juice was neutralised, very little inversion took place, but that some "inversion" took place if one-fourth of the acidity was left. Still, even then, an advantage was apparent. On the other hand, however, if *all* the acidity of the juice was neutralised and a slight excess of lime employed, the resulting *gur* became black. Although there is no difficulty in testing for acidity in the juice with litmus paper, provided a little care is bestowed upon the operation, still it was felt that if the process could be simplified in any way it would be an advantage.

The first experiments which I made this year at Cawnpur had the object of simplifying as far as possible the use of litmus paper. A few words may be said in reference to how this "indicator" is used. As is well-known litmus is a vegetable matter, the colour of which becomes red in the presence of acids and blue in the presence of alkalis.

In last year's experiments lime was added to a certain portion of the juice until that portion became exactly *neutral*, that is, neither acid nor alkaline. For the novice this point of neutrality is, however, a somewhat difficult one to hit off exactly: it is generally easier to detect if a liquid is acid or alkaline than if exactly neutral, and it was to avoid the necessity of arriving at this neutral point, that the first experiments were made. It will now be understood that supposing lime be added to juice until it is in excess, that is, until the juice becomes alkaline, this can be readily detected, for red litmus paper will be changed to blue. Then, however, sufficient juice must be added to render this *over-limed* portion distinctly acid again. Consequently it was considered that if so large a portion as nine-tenths of the juice were limed in this manner, *i.e.*, with an excess of lime, the remaining one-tenth would not be sufficient to prevent the resulting *gur* becoming dark coloured.

EXPERIMENTS with SUGAR-CANE.

Cawnpur.

STATEMENT No. 10.

Showing the effect of neutralising the Juice with Lime, Cawnpur Farm.

Variety of Cane.	Madrasi Pounda, Plots 4 and 5.		Madrasi Pounda, Field A. B.		Saharanpuri, Field A. B.		Dikchan, Field A. B.		Matna, Field 10-11.		Dhaul, Field 10-11.	
Treatment.	Poudrette.		Poudrette = 500 N.		Poudrette = 500 N.		Poudrette = 500 N.		Poudrette = 250 N.		Poudrette = 250 N.	
Juice—												
Cane-sugar . . .	14·48		12·63		13·54		7·81		8·97		10·30	
Glucose . . .	·80		·89		·67		·96		1·19		1·12	
Total .	15·28		13·52		14·21		8·77		10·16		11·42	
Ratio: Total Sugar to Glucose	5·24		6·58		4·72		10·95		11·7		9·80	
	Not limed.	⅔ limed.	Not limed.	⅔ limed.	Not limed.	⅔ limed.	Not limed.	⅔ limed.	Not limed.	⅔ limed.	Not limed.	⅔ limed.
Gur—												
Cane-sugar . . .	64·46	74·34	68·00	68·64	69·69	73·25	56·22	61·80	58·64	69·09	62·49	61·74
Glucose	9·60	6·20	8·61	7·14	6·38	6·23	15·46	13·55	18·02	11·08	15·48	13·86
Total .	74·06	80·54	76·61	75·78	76·07	79·48	71·68	75·35	76·66	80·17	77·97	75·60
Ratio: Glucose per 100 of Total Sugar.	12·96	7·70	11·24	9·42	8·38	7·84	21·57	17·98	23·5	13·8	19·8	18·3

EXPERIMENTS with SUGAR-CANE.

Cawnpur.

In the experiments at Cawnpur two-thirds of the juice was treated with lime until slightly alkaline, and then the remaining one-third of the juice added to it so as to render it acid. In this way somewhat more than two-thirds of the acids in the juice became neutralised.

Moreover, in order to put the process on a practical footing, the liming was performed by the students of the Agricultural School.

The results of the experiments are detailed in Statement No. 10. In all cases some advantage is shown to have been gained from the application of the lime in the above described manner, though the advantage is not so great as it was in some of last year's experiments. In the first three cases, however, the amount of "inversion" which occurred without lime was not great, and the effect of liming is somewhat masked. In the other three cases the proportion of glucose in the juice was already very high; in one of these "inversion" was almost stopped, but in the other two it was considerable.

12. About this time I determined to try to do without litmus paper altogether. I had noticed that the many varieties of sugar-cane juice which I had examined, all contained a colouring matter which was affected by alkalis, and it was clear that if this colouring matter could be utilised as an indicator, instead of litmus, an advantage would be gained, in that nothing but the lime would be required. The colour of fresh cane juice varies and is not in any case easily defined, but it is always more or less greenish-brown. This colour is, however, almost entirely due to insoluble matters and chlorophyl, and the juice itself is almost colourless. The froth which forms when it is stirred rapidly is nearly white. If, however, an excess of an alkali, such as lime, be added, the juice becomes yellow-coloured, a colour which would be much more easily seen if it were not for the presence of the insoluble matters named; the froth of alkaline juice is very yellow. When, however, this yellow colour becomes apparent, it will be found that a considerable excess of lime has been employed and that the juice is strongly alkaline. On this account it was deemed advisable to add lime to only half the juice until it became yellow and then to add the other half of the juice to render it all acid again.

Statement No. 11 exhibits the results of two experiments made at Dumraon in this way in which ordinary solid *gur* was prepared.

EXPERIMENTS with SUGAR-CANE.

Dumraon.

STATEMENT No. 11

Showing the effect of neutralising Sugar-cane Juice with Lime (Dumraon Farm).

VARIETY OF CANE.	"POONA."		"KHARI."	
Manure.	Castor-cake.		Castor-cake.	
Juice—				
Cane-sugar . . .	12·77		10·90	
Glucose . . .	·81		·71	
TOTAL .	13·58		11·61	
Ratio: Total Sugar to Glucose . . .	5·96		6·11	
	Not limed.	Half limed.*	Not limed.	Half limed.*
Gur—				
Cane-sugar . . .	73·36	74·30	70·25	73·41
Glucose . . .	8·36	7·74	6·59	6·24
TOTAL .	81·72	82·04	76·84	79·65
Ratio: Total Sugar to Glucose . . .	10·23	9·43	8·58	7·83

Behea.

STATEMENT No. 12.

Composition of Rab made at Behea, 1897.

	Limed *Rab* No. 1.	Limed *Rab* No. 2.	Limed *Rab* No. 3.	Ordinary *Rab* No. 4.
Cane-sugar . . .	71·69	71·30	68·98	74·90
Glucose	2·22	2·56	4·53	4·84
Insoluble mineral matter .	·13	·14	·15	·23
Lime	·20	·28	·35	·04
Other soluble mineral matter	1·76	1·46	3·70	1·97
Water, etc. . . .	24·00	24·26	22·29	18·02
TOTAL .	100·00	100·00	100·00	100·00
Ratio: Total Sugar to Glucose . . .	3·0	3·4	6·1	6·1

EXPERIMENTS with SUGAR-CANE.

STATEMENT NO. 13.

Composition of the Turbine Sugar from the Rab.

	Turbine Sugar No. 1.	Turbine Sugar No. 2.	Turbine Sugar No. 3.	Turbine Sugar No. 4.
Cane-sugar . . .	95·10	94·02	95·22	90·31
Glucose	·77	1·04	1·06	1·94
Insoluble mineral matter .	·29	·38	·17	·24
Lime	·17	·26	·17	·12
Other soluble mineral matter	·40	·63	·64	·75
Water	·40	·76	·77	2·78
Other impurities . .	2·87	2·91	1·97	3·86
TOTAL .	100·00	100·00	100·00	100·00
Ratio: Total Sugar to Glucose . . .	·8	1·0	1·1	2·1

STATEMENT NO. 14.

Composition of the Syrup and Molasses from the four Samples of Rab.

	Syrup No. 1.	Syrup No. 2.	Syrup No. 3.	Syrup No. 4.
Cane-sugar . . .	46·00	57·32	47·40	51·31
Glucose	4·03	4·29	5·51	6·39
Insoluble mineral matter	·26	·14	·14	·22
Lime	·40	·28	...	·42
Other soluble mineral matter	1·96	2·01	2·36	2·11
Water, etc. . . .	47·35	35·96	44·59	39·55
TOTAL .	100·00	100·00	100·00	100·00
Ratio: Total Sugar to Glucose . . .	8·0	6·9	10·4	11·0

EXPERIMENTS with SUGAR-CANE.

STATEMENT NO. 15

Composition of the Gur made from the four Syrups.

	No. 1.	No. 2.	No. 3.	No. 4.
Cane-sugar . . .	78·55	81·04	70·57	66·42
Glucose	5·31	5·91	9·31	8·97
Insoluble mineral matter .	·26	·77	·58	·32
Lime	·37	·39	·31	·28
Other soluble mineral matter	3·02	2·84	3·73	3·28
Water, etc. . . .	12·49	9·05	15·50	20·73
TOTAL .	100·00	100·00	100·00	100·00
Ratio: Total Sugar to Glucose . . .	6·4	6·8	11·6	11·9

Here again there is evidence that liming was useful, but the amount of "inversion" in the unlimed *gur* was only small. At Behea also, three lots of juice were partly neutralised with lime in the manner above described, and the *rab*, the turbine sugar, syrup, and the *gur* from the syrup, all analysed. Nos. 1, 2, and 3 in the accompanying Statements 12 to 15 are from the limed juice, whilst No. 4 is from unlimed juice. The effect of lime is apparent in Nos. 1 and 2 right through the series and also in the turbine sugar No. 3, and *gur* No. 3, but the *rab* No. 4 is probably better than most. (Compare analyses in Statement No. 9.) It is possible that liming might be carried somewhat further than was the case in the experiments quoted. The degree to which the process might safely go, that is the proportion of juice which might be safely rendered yellow with lime, had to be guessed at. I think it likely that two-thirds of

EXPERIMENTS with SUGAR-CANE.

the juice might be rendered yellow by lime safely without affecting the colour of the resulting sugar.

Hand-centrifugal process.

Turbine sugar.

13. (*f*) ***Handcentrifugal-made sugar.***—In paragraph 9 of *Agricultural Ledger No. 19 of 1896* the object of the Hand-centrifugal Sugar Separator, which Messrs. Thomson and Mylne have been gradually introducing, was briefly explained. Whilst on tour this year I embraced an opportunity which offered itself of determining how much of the semi-refined sugar, which there goes by the name "Turbine sugar" and "Kachha Chini", is obtainable from the *rab* as generally made by cultivators, and the following gives the result:—

Experiment 1.—22½ seers of *rab* gave 11 seers of turbine sugar or 48·8 per cent.

Experiment 2.—26 seers of *rab* gave 13½ seers of turbine sugar or 51·9 per cent.

Thus, judging by the results of these two tests, it may be assumed that about half the weight of the *rab* will be obtained as turbine sugar.

I made some further enquiries as to the relative values of the several materials.

The prices which were current at the time of my visit were: turbine sugar, R5-4-0; *gur* from molasses, R2-12-0, and ordinary *gur* from whole juice R3-4-0, per maund.

Thus, assuming that *rab* yields 50 per cent. of turbine sugar and the rest is boiled down to *gur*, there would be obtained from one maund of Rab 20 seers of turbine sugar worth R2-10-0, and about 14 seers of *gur*, worth R1-0-0, or a total of R3-10-0 instead of R3-4-0 for ordinary *gur*.

The amount of this turbine sugar which is made annually must be very considerable now, and the value may be guaged in lakhs of rupees. It is sent as far as Peshawar and is largely used in sweetmeat-making in addition to the requirements of the sugar refiners.

There is also a larger market for the *gur* prepared from the molasses than I had previously understood. Judging by the analyses quoted in Statement No. 15, it is quite as good as very much of the *gur* commonly prepared from the whole juice. The chemical composition of the several products, *rab*, turbine sugar, molasses and *gur*, have been already dealt with in the previous paragraph.

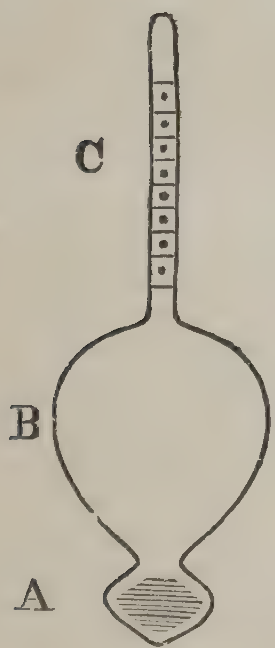
APPENDIX.

To find the percentage of sugar from the density of the juice.

On the use of the hydrometer.

Explanation of the use of the tables.—A few words in explanation may be of service to those who are not accustomed to use the hydrometer.

In the first place it will be well to explain that there are several descriptions of hydrometers made, all of which, however, are essentially the same in principle, and the accompanying diagram represents a very common shape. Occasionally they are made of brass, but more frequently of glass. The instrument may be divided into three parts: A, a small bulb, containing some heavy material such as mercury or shot; B, a larger bulb containing nothing but air, and C, the stem in which is fixed a scale of figures by which the density of liquids is registered. The hydrometer floats upright in liquids, so that the bulb A is downwards and the instrument comes to rest with a part of the stem C above the surface. The degree on the scale which coincides with the surface of the liquid corresponds to its density. Thus in a dense liquid the hydrometer will not sink so far as it will in a lighter liquid. In using these hydrometers the cane-juice or other liquid to be tested is poured into a glass cylinder and the hydrometer then put into it. There is considerable difference between the density of such light liquids as ether and alcohol and heavy ones such as oil of vitriol. On this account it has been found convenient to make hydrometers for liquids of only a certain range of density. Thus, for instance, a series of specific gravity hydrometers might be the following: 600-800, 800-1,000, 1,000-1,200, 1,200-1,400, 1,400-1,600, 1,600-1,800, 1,800-2,000. Twaddell's hydrometers range as follows:—



No. 1, 0°-24°, No. 2, 24°-48°, No. 3, 48°-74°, No. 4, 74°-102°, No. 5, 102°-138°, No. 6, 138°-170°. Thus for sugar juices one would require the specific gravity hydrometer reading between 1,000-1,200 or Twaddell's No. 1.

There are several descriptions of hydrometers made, but only two will be here referred to, namely, the specific gravity hydrometer and Twaddell's hydrometer. The former is commonly used for scientific work, the latter for technical purposes. I find that Twaddell's hydrometers are stocked by the larger firms of apothecaries in India, and they are thus readily available.

APPENDIX.

On the use of the hydrometer.

It will be clear that the scale in the hydrometer stem is purely arbitrary, and as a matter of fact the two instruments here described have essentially different scales. The specific gravity hydrometer registers the specific gravity of liquids, that is, the relative weights of equal volumes of different liquids. Thus, for example, 1,000 on its scale is the specific gravity of water and 1,080 might be the specific gravity of some sample of sugar-cane juice ; this would mean that if we weighed, say, a quart of water and a quart of the juice, we should find that the weights were in this proportion of 1,000 to 1,080.

Twaddell's hydrometer does not register this directly. Water is registered by it as 0, and then for heavier liquids the scale ascends. Nevertheless, this scale bears a simple relation to the true specific gravity and is expressed by the following equation : degrees Twaddell $=\frac{\text{sp. gr} - 1,000}{5}$. Thus, for example, specific gravity $1,075 = \frac{1,075 - 1,000}{5}$ or 15° Twaddell ; and specific gravity $1,060 = \frac{1,060 - 1,000}{5}$ or 12° Twaddell.

It is necessary now to say a word in explanation as to why the temperature of the liquid should be recorded as well as its density. Suppose a cylinder of juice be taken, and the hydrometer floated in it, at, say, a temperature of 65° F. and the density be found to be 12° Tw. (assuming the instrument has been standardised or compared with water at 60° F.). If the jar of juice with the hydrometer be then placed in a can of warm water, so that the juice will gradually be warmed, it will be noticed that the hydrometer sinks lower as the temperature of the juice rises, that is to say, the liquid becomes *lighter* or less dense. In the case quoted, the juice shows a density of 12° Tw. at 65° F. If the temperature rose to, say, 84° F., it would be found that the hydrometer had sunk to $11\frac{1}{2}$° Tw. Or we may suppose we had put the hydrometer into some juice early in the morning in the cold weather of Upper India, we might have observed this density of 12° Tw. and then later in the day as it grew hot the same juice might have registered only $11\frac{1}{2}$° Tw., a change due simply to the juice becoming warmer.

A word may now be said in explanation of the difference between hydrometers standardised at different temperatures. The density of water on Tw. scale is 0°. But manifestly the temperature has something to say to this point. For example, if we put into the jar of water a Twaddell's hydrometer which has been standardised at 60° F., and supposing the temperature of the water is just about 60° F., we shall find the hydrometer sinks to 0° Tw. Now warm the water until the thermometer shows that its temperature is about 84° F., and it will be seen that the water has become *lighter*, just as the juice did in the above-quoted example, and that the hydrometer has sunk below 0° to about $-\frac{3}{4}$° below.

Now take this hydrometer out and put into the water at 84° F., the Twaddell's hydrometer which has been standardised at 84° F. It will be found to register 0° Tw. Cool the water again or put some of the

APPENDIX, On the use of the hydrometer.

cold water at 60° F., in the jar, and it will be seen that the hydrometer has risen a little out of the cooler water, that is, the water has become heavier again and the hydrometer registers about $+ \frac{3}{4}°$ Tw.

It is hoped that the foregoing will explain the difference between hydrometers, why it is necessary to note the temperature of the liquid as well as the density, and what the difference is between hydrometers standardised at one or another temperature. Usually hydrometers are standardised at 60° F., in England, but I find that some of those imported for use in India are standardised at 84° F.

The use of the tables will now be readily explained by a few examples. Supposing in the first place we have a specific gravity hydrometer which has been standardised at 60° F., and that when it is put into a jar of juice, it registers 1,059, and that the temperature of the juice is 72° F. We have, in the first place, to find from Table 1 what the density of the liquid would be at 60° F. Looking along the line of "observed temperature Fahrenheit" we find under 72° the figure "+2" entered as "the amount to be added to the observed specific gravity," consequently 2 is added to 1,059; 1,061 is the specific gravity of the liquid at 60° F. Now refer to Table 4 and under specific gravity 1,061 we find $12\frac{3}{4}$ as the corresponding percentage of sugar.

Example 2.—Supposing we have a Twaddell's hydrometer No. 1 which has been standardised at 60° F. and when placed in a jar of juice it indicates a density of 13° Tw. at temperature 55° F. On reference to Table 2 we find that for any temperature between 49° and 55° F. $\frac{1}{4}°$ Tw. must be *subtracted* from the density in order to find the density at 60° F., because the juice at 55° F. is denser than it would be at 60° F. The density of this juice would therefore be $12\frac{3}{4}°$ Tw. at 60° F. On reference to Table 4 we find that $12\frac{1}{2}°$ Tw. corresponds to $13\frac{1}{4}$ per cent. of sugar and 13° Tw. to 14 per cent. sugar. The juice in question, therefore, contains between $13\frac{1}{4}$ and 14 per cent. sugar or, say, $13\frac{1}{2}$ per cent. which is as near the truth as we can get by this method.

Example 3.—Taking the same hydrometer for another sample of juice pressed may be in the hot part of the day or the afternoon. We find that it registers 16° Tw.,—the temperature being 86° F. From Table 2 we find that for temperatures between 80° and 87° F., we must add $\frac{3}{4}°$ to the reading of this hydrometer in order to find the correct density at 60° F. The density of this juice will therefore be $16\frac{3}{4}°$ Tw. at 60° F. From Table 4 we find that the percentage of sugar for a density of $16\frac{1}{2}°$ Tw is 18, and for a density of 17° Tw. it is $18\frac{1}{2}$. A density of $16\frac{3}{4}°$ Tw. will, therefore, correspond to about $18\frac{1}{4}$ per cent. sugar.

Example 4.—We will suppose that we have a Twaddell's hydrometer No. 1 which has been standardised at 84° F. We have in this case to use Table 3 to correct its reading. A sample of juice is found to have a density of 14° Tw. and the temperature 75° F. On reference to

APPENDIX.

On the use of the hydrometer.

Table 3 we find that for any temperature between 72° and 79° F., we must deduct $\frac{1}{4}$° from the hydrometer reading in order to find the density at 84° F. Thus the density of this juice will be $13\frac{3}{4}$° Tw., and from Table 4 we find that this density corresponds to $14\frac{3}{4}$ per cent. of sugar.

Example 5.—Another example may be given for using this hydrometer. A sample of juice is found to have a density of 10° Tw. at 66° F. On reference to Table 3 we find that for temperatures between 64° and 71° F., we must deduct $\frac{1}{2}$°, thus the density at 84° F. would be $9\frac{1}{2}$° Tw., and from Table 4 we find that $9\frac{1}{2}$° Tw. corresponds to $9\frac{3}{4}$ per cent. sugar.

TABLE I.

To reduce observed specific gravity to specific gravity at 15·5° Centigrade or 60° Fahrenheit.

Observed Temperature Centigrade.	10°-13°.	14°-17°.	18°-21°.	22-25.	26-28.	29-31.	32-34.
Observed Temperature Fahrenheit.	50°-56°.	57°-63°.	64-71.	72-78.	79-83.	84-89.	90-93.
Amount to be added to or substracted from observed specific gravity . .	—1	0	+1	+2	+3	+4	+5

TABLE II.

To reduce observed density on Twaddell's Hydrometer to density at 60° Fahrenheit.

Observed Temperature Fahrenheit.	49-55.	56-63.	64-71.	72-79.	80-87.	88 95.
Amount to be added to or subtracted from density on Twaddell's Hydrometer .	$-\frac{1}{4}$	0	$+\frac{1}{4}$	$+\frac{1}{2}$	$+\frac{3}{4}$	+1

TABLE III.

To reduce observed density on Twaddell's Hydrometer to density at 84° Fahrenheit.

Observed Temperature Fahrenheit.	49-55.	56-63.	64-71.	72-79.	80-87.	88-95.
Amount to be added to or subtracted from observed density on Twaddell's Hydrometer . . .	—1	$-\frac{3}{4}$	$-\frac{1}{2}$	$-\frac{1}{4}$	0	$+\frac{1}{4}$

TABLE IV.

To find percentage of total Sugar from Specific gravity or density on Twaddell's Hydrometer.

APPENDIX

On the use of the hydrometer.

Specific gravity.	1040-41.	1042-43.	1044-46.	1047-48.	1049-51.	1052-53.	1054-56.
Degrees Twaddell .	8	8½	9	9½	10	10½	11
Per cent. Sugar .	8	8½	9	9¾	10½	11	11½

Specific gravity.	1057-58.	1059-61.	1062-63.	1064-66.	1067-68.	1069-71.	1072-74.
Degrees Twaddell .	11½	12	12½	13	13½	14	14½
Per cent. Sugar .	12	12¾	13¼	14	14½	15	15½

Specific gravity.	1075-76.	1077-79.	1080-81.	1082-84.	1085-86.	1087-89.	
Degrees Twaddell .	15	15½	16	16½	17	17½	...
Per cent. Sugar .	16	16¾	17¼	18	18½	19	...

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(Food Substances.)

THE

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1897—No. 4.

MANIHOT UTILISSIMA; ALSO M. PALMATA.

(CASSAVA, TAPIOCA, MANIOC.)

[*Dictionary of Economic Products, Vol. V.,* **M. 216—30.**]

THE TAPIOCA PLANT

CONSIDERED AS AN ALTERNATIVE FOOD-STUFF IN SEASONS OF SCARCITY AND FAMINE.

Correspondence between MR. E. HALLIDAY GUNNING, M.D., HON. LL.D., *and* MR. ROBERT THOMSON *and Her Majesty's Secretary of State for India and the Government of India. A Note on Tapioca Cultivation in Travancore, by* MR. A. M. SAWYER, (*reprinted from 'The Indian Forester,' Vol. XXI., pp. 290—296.*) *Introductory remarks by* THE EDITOR.

The papers reproduced in the following pages on the subject of Manioc or **Manihot** (Tapioca plant) are of special interest at the present time.

Cultivation: Bengal.

During the writer's recent tour through Dinajpur, Rangpur, Bogra, and Jalpaiguri Districts of North Bengal, as also Kamrup, Nowgong, and Sibsagar Districts of Assam, he devoted some attention to the study of the Tapioca plant. He found it being cultivated under the name of *simla-alu* or *simul-alu* (that is to say, the potato from the plant that resembles **Bombax malabaricum**).

Assam.

In Assam it is not, strictly speaking, cultivated, but is used as a hedge plant, the roots being dug up and eaten as required.

As practised in Bengal.

In the districts of Bengal mentioned above there is a more or less regular cultivation. The plant is propagated by stem-cuttings. When the crop is harvested in October the stems are collected and stored in the shade. In May or June, as soon as the rains begin, these are cut up into lengths of nine to twelve inches, and planted out two yards apart. They each give 3 to 4 seers of tubers in

Yield.

October to November. The yield per acre is therefore very large and the crop gives very little trouble.

Travancore.

It may be added in this connection that in Travancore it is largely grown and tapioca is said to be made from it as a regular article of trade.

Conf., pp. 13 et seq. Recommended as a hedge plant and alternative food-stuff.

Its use as a hedge plant—the roots to be resorted to during periods of distress—seems worthy of consideration, especially for Chutia Nagpur and the districts of the Central Provinces that often suffer from scarcity of food-supply. A more extended effort to cultivate the plant would appear, however, to be undesirable, since in most parts of India the people are averse to eating Tapioca.—*Editor.*

Despatch from Her Majesty's Secretary of State for India, to the Government of India, No. 12 (Revenue), dated the 21st January 1897.

Conf. p. 11.

I forward herewith, for the information of your Excellency's Government, a copy of correspondence with Mr. R. Halliday Gunning, M.D., Honorary LL.D., on the subject of the introduction into India of the Manioc or Mandioca (Tapioca plants) of South America as an alternative food-crop in times of prolonged drought and famine. Both the Bitter and the Sweet Cassava plants are well known throughout India, and the Bitter Cassava is cultivated for food in Assam. It might be found advantageous to extend its cultivation, and that of the Sweet Cassava, to other parts of the Indian Empire, as a reserve resource in times of apprehended famine.

Dated London, the 26th December 1896.

From—R. H. Gunning, Esq., M.D., Hon. LL.D.,

To—The Secretary of State for India.

Impressed, when residing in Brazil, by the gigantic mortality and expense resulting from famines in India, and then believing, as I still believe, that the planting of Manioc (called in Brazil Mandioca) would be an effective means of preventing or mitigating such famines, I brought the subject before the late Sir George Buckley Mathew, Her Majesty's Minister at Rio de Janeiro, and my ideas being highly approved by him and other Foreign Ministers and by the local press, I was advised to write to the late Lord Derby, who was then (in 1874) Minister for Foreign Affairs, and His Lordship sent my letter to the India Office, then held by Lord Salisbury. I think my scheme was understood as a wish to introduce Manioc as a substitute for rice, whereas my object was only to introduce it as an alternative food, or precaution against famine in times of prolonged drought. Somehow the subject was allowed to drop, but the present visitation of famine being so serious (see cuttings enclosed from to-day's *Times*), and other famines being likely to recur, I have thought it my duty to draw public attention to it, and in this view I asked the advice

and help of my kind friend Lord Lorne, as you will see by the enclosed correspondence. I am blind and in indifferent health, and in my 79th year, but I should like very much if your Lordship will study the subject, as I feel convinced that the introduction of this God-ordained food for drought and famine into many parts of India out of communication with railways would save millions of pounds and millions of lives. Livingstone, calls it "the staff of life" in Africa, and it is a universal food in Brazil, Chili, Peru, and Central America, in all of which countries we never hear of famines, though there are often very long droughts, and there is no reason that I know of why it should not be planted in every locality in India where needed.

My scheme can be of no use for the present famine, but the plant could be introduced by millions in a few years. In the first year the roots can be availed of for food, and the stems and branches (each plant giving fully 100 slips) can be handed on to fresh planters, so that within a few years all the countries most needing it could be supplied. The expense of getting branches from some parts of India, Africa, or Brazil would only be the expense of the carriage, as the branches are only used as firewood when the food-roots are taken away. The Manioc I am speaking of now is not the poisonous but the sweet kind,—the **Manihot utilissima**,—and I shall be happy to have some boxes of cuttings from the best varieties in Brazil sent to the British Consul at Rio de Janeiro for transport to India. I sent some specimens to the Royal Botanical Society, and I could show the root and plant to anyone your Lordship might appoint to investigate the matter. I am leaving town for Torquay on January 9th, but till that date I shall be happy to wait on your Lordship, or anyone you may appoint, to make further explanations.

Dated Palmeiras, Brazil, the 13th September 1874.

From—R. H. Gunning, Esq., M.A., M.D., etc.,

To—The Right Honourable the Earl of Derby, D.C.L., Her Britannic Majesty's Secretary of State for Foreign Affairs, Foreign Office, London.

The severity of the famine in India has been alleviated as only a wealthy, energetic, and Christian nation like England could do, but at what a sacrifice of wealth and energy to England, and with what misery of mind and body to millions of her subjects in India. Besides plans of irrigation, and facility of supply from other localities by railroads and canals, what other auxiliaries are there? One occurs to the writer, and, deeming it of great importance, he feels it a duty to bring it under your Lordship's notice. He does it the more easily that your Lordship's interest in the progress and wellbeing of India is well known and, not less, your Lordship's wide information and sound judgment as a philosophical and practical statesman. Thus interested in our Eastern Empire, and thus mentally qualified, my ideas and argument will be better appreciated.

MANIHOT utilissima.

The Tapioca Plant considered as an alternative

The principal food in India being rice, and rice depending on rains, what when these rains fail? My idea, my suggestion is, for every planter or landholder to have at hand the Cassava or Mandioca plant, the root of which is of the same nature as rice, as delicious as the potato, and keeps fresh underground for years, indifferent to great changes of heat or cold. It is a universal article of food in Brazil, being used from north to south, and east to west, in the whole Empire. Tirhoot is in latitude north what Santa Catherina (a great field for Cassava) is south, but Mandioca conforms to a great diversity of climate, season, and soil. It is easily got, planted, cultivated, and gives an immense return—six times greater than wheat, according to some! It can be grown easily, seeing it is a large branchy arbuscle, and the numerous knots or leaf-marks on the branches are each a new plant. In cutting the branches to plant, the slips are made about three inches long, and include two or three of these knots, and yet each plant will give from, say, twenty to sixty separate slips, and therefore as many new plants. Once started with a good number of plants, the roots of which can be availed of in eight to twelve months, few years would be required to distribute it over whole territories the first holders merely keeping a few branches to replant and handing over the rest to neighbours; for unless to plant, they are of little value except as firewood. Then it carries easily, as being succulent the branches will keep alive two or three months with little care. It has been introduced into the West Indies and Africa—why not into India, in these times of fleet steamships and direct routes? Boxes of plants could be sent from Brazil, or perhaps Mandioca may be had in Portuguese India, the Cape of Good Hope, or somewhere nearer than Brazil. The planting is very simple, and may be done in any soil, but a soft or sandy soil suits best, the tuberous root developing more easily when there is little bind in the soil. Once the surface of the ground is cleaned by a broad hoe, slight notches two or three inches deep are to be made a yard or two apart, and the cutting laid in and lightly covered. If the soil is deep or sandy, it may be raised into little heaps or ridges, and the slips then placed in the same way. The planting can be done during the whole year, but the best time is when the cold season is ended, when the leaves have fallen and when it is quite ripe. Soon the pretty five-partite leaves show above ground, and all the further cultivation needed is to weed or hoe round it (pulling the earth against the plant) twice or thrice during nine months, when the plant will have flowered and the roots will be ready to eat. But they are larger and more mealy when twelve months old, and keep growing for two years longer. There are two varieties or species of Mandioca, one with a sweet root (**Manihot Aipi**), the other bitter* (**Janipha Manihot**) and poisonous from containing prussic acid in its juice. But with this juice pressed out or dissipated by heat, it is innocuous. To common observation they seem

* Now **Manihot utilissima**.—*Ed.*

alike, but it is easy to see the difference on looking closer. In the poisonous kind the leaves and summits of the branches are darker, and the roots have a purple hue under the cuticle which is wanting in the sweet kind. But the easy test is to taste the broken root. One is sweet like almonds, the other bitter and repulsive. Better only to introduce the sweet at first, in view of its being used quickly and extensively as the potato. Afterwards, and where mills can be erected, the bitter kind could also be cultivated. It is said the bitter yields more than the sweet, but I have not observed it so. I know no reason for growing the bitter, except for better repelling attacks of insects, cattle, etc. Both grow well here, but the bitter is safer against appropriation by bad neighbours or their cattle. Each plant gives from three to six long thick roots, weighing conjointly from half a stone upwards, and covered with a brown coarse skin. This thick skin being peeled off, the rest can be boiled entire, or if large, it can be cut up like the potato or it can be roasted in the ashes. It is nice and delicate prepared in any of these ways, and in Brazil is relished by rich and poor even more than rice. In any case, if not always a luxury, every one would find it so in times of starvation. Enough at first to have it propagated among the poor, to be ready in seasons precarious to rice. A small garden or spot of ground will grow enough for a family. Surplus branches are always abundant, and they will grow in any ground, Women or children can easily attend to the plants, and the roots need no storage, as they keep fresh and even increase in the ground. I should think that all would be glad to have Mandioca, not only as a preventive of famine, but as a variety or change from rice. Rice and Mandioca are the same in composition. Both have a large preponderance of amylaceous matter and little gluten or flesh-forming element, but for this reason they suit the climate and habits and render the body less liable to diarrhœa, dysentery, etc. The great object, I repeat, should be to have it spread rapidly over different districts, as a good root to be used as potato, but afterwards its other uses may be availed of.

The peeled root is grated on a common grater, by a handwheel, or by one driven by machinery, into a soft pulp, and this, after the water is pressed out, heated in copper pans, is the farina of universal use. From this can be made tapioca, and a nice starch known here as "polvilho" and in England as Brazilian arrowroot. The dry farina is used alone or with many dishes. The *rationale* is, it necessitates and stimulates saliva and thus assists digestion. Made into a paste with boiling water, it is used with fish, or fried in little cakes. It keeps in bags for a long time without souring, and so can be carried from one district to another in the usual way of commerce. The juice of the bitter kind is made in the West Indies into the famous and much-prized "Casareep" or "Cassiripe," and fermented it gives a vinous spirit.

In fine, the idea is not to substitute the cultivation of rice and the habits of the people, but that they should have a variety of the same kind of food as rice, and one fitted to endure in droughts when cereals fail.

M. 216—30.

MANIHOT utilissima. The Tapioca Plant considered as an alternative

The Quina plant has been acclimatised and successfully introduced into India for a long time. A few years ago I had the honour to send plants of Ipecacuanha to Sir Robert Christison and Professor Balfour of Edinburgh University, to have it propagated in India, for the treatment of dysentery, as the supply from Brazil was getting precarious. Both have a wide application and significance in a country where intermittents and dysentery abound, but much more significant and much more beneficial and economical will be the wide introduction of Mandioca, seeing that millions of human beings and millions of pounds sterling are involved in the misery of a famine.

If my suggestion is useful, and if I can be of any use in carrying it out, my services are at your Lordship's orders, and I shall be highly rewarded if it should tend to prevent, or even to alleviate, the misery of future famines.

Since writing the above, my attention has been drawn to references to Mandioca in *Livingstone's Travels.* In the 17th and 21st chapters he alludes to it in terms which confirm my ideas, and are fitted to encourage your Lordship's attention to the subject. He speaks of it as having been introduced by Portuguese missionaries and traders. In chapter 17 he says: "Every valley has gardens of Mandioca, which here is looked upon as the staff of life. Very little labour is required for its cultivation," etc. He is speaking of the bitter kind badly prepared. In chapter 21—"they subsist chiefly on the Manioc, raw, roasted, or boiled. It bears drought well, never shrivelling like other plants when deprived of rain, never eaten by weevils, and so little labour is required for its cultivation that it is commonly sold in Angola for one penny for ten pounds."

Dated Foreign Office, London, the 14th October 1874.

From—T. V. Lister,
To—R. H. Gunning, Esq., M.D.

I am directed by the Earl of Derby to acknowledge the receipt of your letter of the 13th ultimo, recommending the introduction of the Manioc tree into India, and I am in reply to inform you that His Lordship has referred your communication to the Secretary of State for India.

Dated Foreign Office, London, the 18th November 1874.

From—Lord Tenterden,
To—R. H. Gunning, Esq., M.D.

The Earl of Derby has communicated to the Secretary of State for India in Council your letter which was forwarded to this office by Her Majesty's Minister at Rio de Janeiro, containing a proposal relative to the introduction of the Manioc tree into India as an additional source of food-supply; and I am now directed by His Lordship to express to you the

thanks of the Marquis of Salisbury for your suggestions on this point and for your interesting account of the cultivation of the tree in question.

I am at the same time to state to you that the **Janipha Manihot*** is already largely cultivated in India, and it would not therefore, in the opinion of the Indian Government, be necessary to import plants from Brazil in the event of the cultivation of Cassava being largely extended.

Dated 12, Addison Cresent, Kensington, London W., the 21st December 1896.

From—R. H. Gunning, Esq., M.D.,

To—Lord Lorne.

I hope you will excuse me for trying to enlist your help and sympathy with my scheme for the prevention of famines in India. I feel confident that it only requires to be known to be adopted by the Indian Government. I wonder that it was not adopted when I suggested it now twenty-two years ago, and I can only explain its non-adoption by believing that my idea was not well understood. You will see, by reading the first paragraph of Lord Derby's second letter (18th November 1874) that I was understood to propose "the introduction of the Mandioca plant into India as an additional source of food-supply," but that was not my whole meaning. I meant it only as an alternative food, which could be used instead of rice during long droughts, and therefore as naturally fitted to prevent famine. This is the point which has been overlooked and should therefore now be attended to. In the third last paragraph of my letter to Lord Derby on the subject of Mandioca, what I said runs thus: "The idea is not to substitute the cultivation of rice and the habits of the people, but that they should have a variety of the same kind of food as rice, and one fitted to endure in droughts when cereals fail." This recommendation is as forcible now as it was then, and I do not believe it possible to gainsay the soundness of the advice, though somehow it has not been carried out.

Having influenced the Brazilian Government to serve Her Majesty's Minister in the question of the great mortality of British immigrants, as you will see by the enclosed letter, we became fast friends, and it was at his instance that I was induced to write to the then Foreign Minister, the late Lord Derby, and, having done so, I left the question alone, and it has lain dormant till now that a great famine is again attracting public attention and demands fresh consideration. The many railways made since then, the great extension of wells and irrigation, and the large employment of hundreds of thousands on public works, will mitigate much suffering and mortality, but there will still remain a great deal not overtaken by such means, but which could be met by Mandioca. My plan cannot serve the present famine, but should be introduced to serve against future droughts.

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* *Vide* Note on page 4.

It occurs to me that the subject of my paper might be brought before the Secretary of State for India, who could bring his best advisers to discuss the *pros* and *cons* with me. Or it could be discussed in the Imperial Institute before a select audience of experts connected with India and Africa, who could hear and say all that is necessary for the acceptance or rejection of the scheme. Though old and blind and in indifferent health, I will try to meet any who know the subject, and give them all the information in my power. Men like Stanley, Selous, Bishop Tucker, and others, who know much of Africa, could assist and bear testimony to the thesis that Manioc is God's natural provision against droughts and famine, and is the surest means of saving people when drought destroys rice and other kinds of food. In short, you have position, and talent, and patriotism to take this great national question under your ægis, and I appeal to you to do so in the interests of your Indian Empire.

If you could arrange a meeting of experts, I think I could take a Mandioca plant with its roots to show better what I mean. At least I believe there are some of my plants in the Royal Botanic Gardens. I have to leave London on January 9th, and would take it as a great kindness if you could see me on the subject after reading the accompanying papers.

With much respect and all good Christmas wishes.

Dated Osborne, the 23rd December 1896.

From—LORD LORNE,
To—R. H. GUNNING, Esq., M.D.

The matter of the cultivation of the Manioc would be a very good subject for a paper to be read for you at the Imperial Institute. I shall not be able to attend any meeting in London before January 9th, the date you mention as that of your departure for the south. I am sure that any suggestion addressed by you to Sir F. Abel at the Imperial Institute with regard to the reading of a paper to be contributed by you would receive respectful attention.

Lord George Hamilton would also give you information up to date with regard to the cultivation in India of the Manioc.

Wishing you a very happy Christmas.

Dated Rio de Janeiro, the 9th November 1873.

From—SIR GEORGE BUCKLEY MATHEW,
To—R. H. GUNNING, Esq., M.D., Palmeiras.

I am instructed by Earl Granville to convey to you the special thanks of Her Majesty's Government for the great kindness you have shown towards the British immigrants to Brazil.

Permit me in fulfilling this pleasing duty to add my sincere acknowledgments for the great trouble you have taken in behalf of these ill-used and indigent people.

No. 444, dated 8th March 1875.

From—The Secretary to the Government of the North-Western Provinces,

To—The Secretary to the Government of India, Department of Revenue, Agriculture, and Commerce.

In reply to your letter No. 1386, dated the 30th December last, I am directed to submit, for the information of His Excellency the Governor General in Council, a report* by the Superintendent of the Botanical Gardens, Saharanpur, on the cultivation of the Tapioca or Manioc tree in India.

* No. 256, dated the 18th February last.

No. 256, dated 18th February 1875.

From—The Superintendent, Botanical Gardens, North-Western Provinces, Saharanpur,

To—The Secretary to the Government of the North-Western Provinces.

I have the honour to acknowlege the receipt of your docket No. 120 A., dated the 16th ultimo, with enclosures, regarding the cultivation of the Tapioca or Manioc bearing tree, and recommending its introduction into India as a food-affording stuff in times of scarcity or famine. Nowhere in the North-Western Provinces has the Tapioca plant **Janipha Manihot** or **Manihot utilissima** been cultivated for its Tapioca or Cassava which is known under the names of Mandioca Farenha or Farine de Manioc, and both of which are prepared from the Janipha roots, of which there are two varieties, the bitter and the sweet. The tapioca is prepared by rough scrapers which grind the tubers to powder; the starch is then washed out of the pulp and dried upon hot plates and kept stirred by iron rods, which break up the pasty mass, and give, in drying, the very irregular rocky appearance peculiar to tapioca. In making Cassava the starch is not washed from the pulp, but the pulp is dried upon hot metal plates, and afterwards roughly powdered. This rough powder, according to its fineness, is designated by the names above given. Tapioca used to be extensively grown at Alipore, Calcutta, by Messrs. Speede, where now the arrowroot produced is of high repute. That the cultivation of the Janipha is still continued I am not aware. Into the Bombay Presidency the Tapioca plant has been introduced in many localities. What kinds have been introduced—the sweet or the bitter Cassava—is not mentioned, but probably both. The bitter is poisonous, but the poisonous principle is easily dissipated by washing the grated powder or by heat. But in the Dekkan the size of the root is not such as to compete with the Potato

MANIHOT utilissima.

or Sweet Potato. In Eastern Africa it is cultivated very largely, and in the Island of Zanzibar or the west coast in Congo and Guinea, it is also abundantly cultivated. From Brazil it has also been introduced into the Mauritius, Madagascar, and Ceylon. It also now grows abundantly in most of the West India islands. For the North-Western Provinces the plant is not adapted, as it is liable to be injured by frost. I have already pointed out that it has been extensively cultivated in the neighbourhood of Calcutta, and is well known in the Madras* and Bombay Presidencies. If, therefore, it be deemed necessary to try its cultivation on a large and useful scale, there will be no difficulty in procuring plants, and it ought to be carried out in the Bengal, Madras, or Bombay Presidency.

The observations of Dr. Gunning regarding its introduction into India are interesting. But the above remarks show that the Cassava or Mandioc yielding plant (**Manihot utilissima**) is already well known, and its cultivation not carried on on an extensive scale because it does not pay. That it will grow in dry places is worthy of attention and experiment as the root in times of scarcity might be usefully employed as food by the poorer classes.

No. 14 G., dated 4th March 1875.

From—The Superintendent, Royal Botanical Garden, Seebpur, Calcutta.

To—The Assistant Secretary to the Government of Bengal.

I have the honour to acknowledge receipt of your endorsement No. 69, Financial Department, Agriculture, dated 7th January, giving cover to certain original papers (herewith returned enclosed) concerning the cultivation of the Manioc or Manihot plant in India.

2. In reply, I have the honour to state that on enquiry I find that the plant is not grown in the North-Western Provinces, Oudh, Punjab, or Central Provinces, except occasionally as a curiosity in gardens. In Bengal gardens it is more frequently met with, and still more frequently so in Burma.

3. It has in no part of Continental India been much appreciated by natives. The natural acridity of the part used, prior to manipulation, is much against its introduction as a staple food. The plant is, moreover, one which requires a good supply of water, and would fail as a food-crop in seasons when rice also fails from that cause. It could not, therefore, be trusted to as a substitute for rice.

Should it be wished to encourage the cultivation of Manioc in Upper India, I believe it would be unnecessary to import supplies of plants from South America, as enough could be collected in India to form a distribution nursery.

* Ainslie's Mat. Med., Vol. I, p. 429; Pareira, Mat. Med., Vol. II, Pt I, p. 428.

Despatch from Her Majesty's Secretary of State for India, to the Government of India,—No. 64 (Revenue), dated the 22nd April 1897.

Conf. pp, 2.

In continuation of my despatch No. 12 (Revenue) of the 21st January last, relating to the introduction of the Manihot (Tapioca or Cassava) plants of South America into India, I herewith forward, for your Excellency's information, a copy of a letter* on the same subject received from Mr. Robert Thomson of Lan Cayetano, near Bogota, in the Republic of Columbia.

* Dated 25th January 1897.

Dated Lan Cayetano, the 25th January 1897.

From—Robert Thomson, Esq.,

To—The Right Honourable the Secretary of State for India.

I have the honour to submit, for your Lordship's information, the following remarks relative to an important food-yielding plant cultivated in this country, it having occurred to me that the cultivation of this plant on a large scale in India would, in all probability, mitigate the calamitous effects of famine.

This plant, **Manihot utilissima**, is cultivated extensively in South American countries. It is also generally dispersed throughout the West India islands. In Jamaica and other islands two or three varieties of this plant are cultivated to a limited extent for the production of starch and farina from the tubers. One of these varieties cultivated in the West Indies is noxious. In Jamaica the plant is called cassava, in Colombia yuca, in Brazil manihot or mandioc.

In reference to this plant the *Ceylon Directory* for 1891-92, says:—

" The check put by the Ceylon Government on the wasteful system of 'chena' cultivation—the sowing of grain on burnt-off forest land—has induced a good many of the Sinhalese to turn their attention to the cultivation of cassava, an article which might be made as widely useful for feeding human beings and cattle in Ceylon as it is in Brazil. . . Cassava is one of the principal articles of food in tropical America, the equivalent of the potato in temperate regions. It was probably introduced into Ceylon by the Portuguese, but never much cultivated till of recent years. . . . Bennett in his 'Ceylon and its Capabilities' takes credit for being the first, about 1820, to introduce 'the sweet cassava' or mandioc into Ceylon, which he considers the root most fitted to be a substitute for rice, but he complains that very little was done by the natives to cultivate it generally, although so easily accomplished, and the produce so nutritious."

It is not quite clear whether the tuber itself is consumed as an article of food in Ceylon, or whether, as in Jamaica, it is employed exclusively for the extraction of farina and starch. Anyhow it would appear that the

peculiar merit of this plant bespeaks for it an important position among the cultural products of India. This merit, presumably, is not known in the East, and it is not adequately appreciated in Columbia nor throughout South America.

In Columbia, as well as in other South American countries, the large tubers are extensively consumed as an article of food. In this country, too, it is noteworthy that some twenty varieties are known in cultivation, some growing in rich soil and some in exhausted or impoverished soil. As an article of food the tubers of several varieties are highly esteemed, commonly esteemed, when quite fresh, in preference to potatoes, which, it may be mentioned, are largely cultivated on the uplands. To these advantages, and they are considerable, another may be added, that is, in Columbia manihot or yuca grows from the level of the sea up to full 6,000 feet. Hence it may be cultivated over a considerable range of latitude. But its peculiar, and most commendable, merit consists in its capacity to flourish in regions not only where prolonged droughts are experienced, but also in comparatively desert regions. Hence it would be a precious adjunct to rice cultivation.

In a recent article in *The Times* of London relative to the impending famine reference is made to a document issued by the Bengal Department of Land Records and Agriculture, which shows that during last June the rainfall, on which the starting of the winter rice crop depends, was abundant in certain districts of Bengal and deficient in others. "Throughout July, August and the first fortnight of September the rainfall was insufficient for the requirements of the winter rice crop in most parts of Bengal."

Touching manihot or yuca I may here observe that its constitutional flexibility enables it to withstand conditions of drought incomparably less favourable than those indicated for rice. Furthermore, I may state that there is no other important food-plant capable of thriving side by side with manihot in districts defaced by disastrous droughts. Thus, where all surrounding vegetation is scorched by tropical drought, where cattle and other animals, roaming over a wide expanse, are reduced to dreadful straits and perishing, this plant maintains its irrepressible vigour.

In this connection it is interesting to note that an important rubber-yielding tree, introduced to India by Sir Clements R. Markham the Ceara rubber of commerce, **Manihot Glaziovii**, is a species of this food-yielding plant. As is well known this rubber tree luxuriates in decidedly arid regions.

Manihot or yuca is propagated with remarkable facility : small pieces of the stem are set in the ground, thus to form the plantation. It attains a height of from three to five feet. On the hot plains crops are secured in eight months ; on the uplands from 4,000 to 6,000 feet, in from ten to twelve months. The entire crop is not obtained at a single digging, and this is an advantage where severe droughts are experienced, but

intermittently as the tubers arrive at maturity ; thus the cropping season is spread over several months. The market price of tubers in Columbia when abundant, is, in English money-value, half-a-crown per quintal. Doubtless the tubers could be produced in India for one-third of this sum. The labour required to produce this article stands at *a minimum*. Potatoes here cost three times more than manihot tubers. Under very favourable circumstances one arroba (25 lb.) is obtained from a single plant. But allowing an average of five pounds per plant ten tons per acre would result—they are planted a yard apart.

In a report of mine presented to both Houses of Parliament twenty years ago, "the Products of Jamaica at the Philadelphia International Exhibition, 1876," in reference to farina or "meal" from manihot (cassava), I stated that the plant grows best in dry localities, and that under high cultivation twenty tons of tubers were obtainable per acre.

In conclusion, it may be mentioned that there is some ground for believing that when this plant acquires importance in India as an adjunct to rice, the following passage from a recent issue of *The Times* on the subject of famine in India shall be no longer valid :—"But if the rain will not fall the land cannot be cultivated and agricultural labour of every sort ceases. Then comes the sudden outburst of despair, when, as in 1866, hundreds of thousands of men and women and starving children fly from their homes in the vague hope of relief elsewhere. In India a population on the drift is a population doomed."

TAPIOCA CULTIVATION IN TRAVANCORE.

TAPIOCA CULTIVATION IN TRAVANCORE.

Note by MR. A. M. SAWYER, *reprinted from 'The Indian Forester,' Vol. XXI., pages 290—296.*

Introduced by the Portuguese in their early settlement at Goa, about the commencement of the sixteenth century, the Bitter Cassava or Manioc, familiarly known as the Tapioca, has been cultivated on the West Coast ever since. But nowhere, perhaps, on that undulating, palm-fringed seaboard has it thriven so well as within the flowery dominions of His Highness the Maharajah of Travancore, where the soil and climate are variable and equable enough to suit it as well as many another tropical South American species like itself. With an abundant rainfall, a gorgeous and invigorating sunshine, and a perennial dew, evergreen species, indigenous and introduced, many and varied, live and thrive. Under these conditions, that a hardy EUPHORBIA like the Tapioca, indifferent to soil and unmindful of all but extremes of climate, should, when brought under the rude cultivation of the Malayali peasantry, cover extensive areas of both hill and dale, must pass without exception.

Towards the middle of October or the beginning of November, when the north-east monsoon is usually at its height, suitable areas, often

TAPIOCA CULTIVATION IN TRAVANCORE.

several acres in extent, are selected for cultivation. The soil being then soft, moist, and easily worked, is either then deeply hoed or ploughed over, and the surface laid out in mounds or platforms each from two to three feet square, and about a foot high. Sometimes circular or rectangular patches, a yard in diameter, are prepared. The platforms and patches are, in some localities, dressed with ashes, leaves, or cattle-droppings, but they are, especially in free, loamy soils, usually let alone. A sufficient number of stems for stocking the area are selected from the previous year's growth, which is either still standing or but recently removed. Each stem is cut up into several little bits varying from six to eight inches in length, care being taken to, in so doing, secure for the plantation only the lower and more mature portions of the stems. Should there be too much rain, the cuttings are kept under cover until a favourable break in the weather occurs; for, if put out in water-gorged soil, they are liable to decay. It is also for this reason that the Malayali selects a well-drained locality—usually a hill-side. But if it be only showery weather and the area well drained, the cuttings are put into the beds directly they are prepared. A bed or patch is considered fully stocked if it hold two or three cuttings which are put down each at a slant of about 60 degrees, and buried in the soil for nearly two thirds of their length. Varying from ten days to a fortnight of their being put out, the cuttings strike root, and the young shoots come up vigorously in light-green tufts of pretty palmate leaves. It is interesting to note that the earliest leaves are usually small, and either three or five lobed, but these are soon supplanted by larger and seven-lobed ones arranged on the stems in a close, alternate phyllotaxis. While the leaves are emerging in all directions over the gradually elongating, wand-like stem, the numerous roots, white and thread-like, radiate from its base into the cultivated area around. In a month or two after the cuttings are put out, the lateral development of their roots begins, and in another eight or ten months they will, in average soil and under ordinary cultivations, have sufficiently developed to be dug up for use. But, as a rule, the roots are allowed to remain in the soil for two months more, in order that the cultivator may, by falling in with the ensuing wet season, secure for the future crop the best results. The rotation of the crops is thus maintained in an uninterrupted annual cycle fixed by the monsoon rains. But should the rains be late and the market favourable, the Tapioca is dug up as soon as it matures, and, as this would be towards the end of the hot season, the new plantation is started at once, but copiously watered once every three or four days until the rains are fairly on. It is said that, so far from interfering with the normal growth and development of the Tapioca, this hot-weather cultivation yields good enough results to quite repay the extra labour it entails. Indeed, the scarcity of water towards the close of the hot weather alone prevents the practice being more largely adopted. Again, a peculiar race of the Tapioca, which is cultivated here, yields two crops in the year; the first of these is, at the end of six months, harvested

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in March, one of the hottest months of the year. As the stems cannot be kept for any length of time without drying, the plantation of the ensuing season is started forthwith, the cuttings being watered until the April showers begin, after which the young plants are left to themselves. The hot weather, though short, is sometimes, and especially of late, very oppressive; but the plants rarely fail, except in extremely stony or sandy soils, and it is the experience of the Malayali that the roots produced by these hot-weather plants are more wholesome and delicious than those yielded by the previous cool-weather ones.

The yield of Tapioca varies with the soil, the amount of care bestowed on its cultivation, the nature and quantity of the manure used, the rainfall, and the particular race or variety cultivated. Although it grows on almost any soil—from stony laterite through gravel to sand and even clay—it thrives best on a well-drained, soft, sandy loam, with an admixture of humus. Stony soil interferes with both quantity and kind, gravel tends to contort the roots often to such a degree as to unfavourably influence their appearance and market value, while clayey soils, always cold, prevent their developing to normal dimensions. Again, the larger the quantity of manure used, the better the yield and the more farinaceous the roots. Ashes or ashes and leaves give the best results, while cow-dung or other cattle-droppings frequently only injuriously affect the quality, though they improve the quantity, of the roots of the more nauseous varieties.

A well-grown healthy root is generally about two feet long, three inches in diameter, and between six and eight pounds in weight. It is generally a little thicker at the attached end, and tapers gradually to a more or less fine point at the free end. The usual colour of the thin outer skin of the root is a pale brown, a stout, tough, white sheath of inner skin closely investing the delicate substance of the root itself. On breaking across it, this brittle substance, turgescent with milky farina, is seen to intimately adhere to and lie around a compact vein of dense fibrous tissue that runs through the centre of the root for its entire length. This vein is probably the original thread-like fibre around which the farinaceous substance is subsequently developed. The root contains the greatest quantity of farinaceous material in from ten to fifteen months after the cuttings are put out, but if allowed to remain in the soil after that time, it soon grows woody, and ere long deteriorates into a soft, spongy mass, the tough fibrous core at the centre being replaced by a narrow canal containing pulpy decaying fluid of grey cellular matter. It is also interesting that, under ordinary conditions, the Tapioca root seldom bifurcates or divides in any way, and that even root-fibres are few and far between; so that absorption of the requisite substances from the soil takes place chiefly through the epithelium of the root itself.

The cultivation of the Tapioca by the hill-men of Travancore is even ruder than that pursued by their more enlightened brethren of the low

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country. Every year, towards the close of the hot season, extensive patches of forest are cut down and burnt; and, as soon as the monsoon rains have descended, different kinds of paddy, *ragi*, maize and Indian-corn, chilies, *dal*, and other seeds and cereals, are sown broadcast and hoed into the soil. Tapioca sticks, too, are put down here and there over the area, and what with the wood-ashes, the humic accumulations of years and the grateful showers, a motley assemblage of plants soon covers the clearing. Each grain is harvested as it matures, and, in due season, the Tapioca, too, is pulled up. Directly they are taken up, the roots are washed, peeled, and cut up into little irregular pieces which are strewn over mats made of the large Esta reed (**Beesha travancorica**) or, what is more usual, upon the bare outcrops of sheet-rock so common on the higher hills; and the sun soon hardens them into the flinty white chips familiarly known as *kani marachini* ("the hill-man's woody potato"). As a rule, the hill-men cultivate just enough grain and Tapioca to meet their requirements for six months of the year, precariously subsisting for the remaining months on wild yams, bulbs and roots. The more forward among them, however, who shrink less from their cultured congeners of the low country, frequently barter some of their produce in exchange for salt, knives, cloths, and other necessaries and luxuries of life. When this is done it is that their excellent Tapioca finds its way to us. This hill-tapioca is much prized by the poorer inhabitants of the outlying towns and villages, because it is believed that the varieties cultivated by the hill-men are generally harmless, and that, for the rest, any nauseous or bitter principle that may remain is efficiently removed by the thorough drying which the roots undergo.

The various processes adopted for removing the poisonous principle of the root, which is now admitted to be some form of hydrocyanic acid, are interesting. Certain varieties, which under the name of the Avians or Boilables are considered harmless, are eaten plain, or made into curry after a single boiling. They are also frequently roasted and eaten with fish curry. The more poisonous kinds are boiled several times, the water being strained off after each boiling. When this process is adopted, the root, after each boiling, is tested; should it taste sweet, it is boiled again, and this is repeated until the peculiar sweetish flavour disappears. An extremely nauseous variety known as the "White Tapioca" has to be boiled at least seven times before it becomes fit for food! Again, the roots of certain other varieties are cut up transversely into thin circular or oval slices, which are dried and then boiled. Frequently the slices are boiled several times and then dried; but when so constantly boiled, the Tapioca, on coming to be cooked, is tough and insipid to the taste and certainly less nourishing. Should the bitter kinds be insufficiently boiled before they are used, violent vomiting, attended with severe pain over the region of the throat and stomach, ensues, the victim grows drowsy, and general prostration and collapse soon follow. The same symptoms are produced by drinking the water in which the roots are boiled. When

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eaten with sugar, jaggery, or molasses, the nausea is very pronounced, and the comatose condition sets in sooner; on the other hand, cocoanut cocoanut-oil, curds and tamarind juice act as vigorous and grateful antidotes, while a solution of assafœtida in water is given to goats and other cattle that are frequently poisoned by eating the leaves of the more nauseous varieties.

Under the local names of *Marachini* (Woody Potato) or *Kappa Kelangu* (Ship Potato), about seventeen commonly recognised varieties of the Tapioca are cultivated in Travancore. But these are evidently only races descended from a few distinct varieties and differentiated through long and peculiar forms of cultivation, not to speak of the powerful influences of soil and climate. These races, proportionate to the bitter principle they contain, may be conveniently brought under one or other of two heads—the Avians or Boilables and the Maravans or dark races. For purposes of study, the following classification has accordingly been found useful:—

I.—*The Avians or easily boilable kinds*, characterised by little bitter principle:—

(*a*) *Pacha Avian* (green boilable).—Leaf-stalks pink along their upper surfaces, but green beneath and at their origin with the blade and insertion at the stem; stems 2 inches in diameter, light green; average height 12 feet; flowers rare; roots pale red, large; average weight 15lbs. each; mature after one year.

(*b*) *Cheenee Avian* (Potato boilable).—Leaf-stalks and stems pale yellow; stems delicate, usual height 5 feet; flowers after one year; roots white, and, like the **Ipomea Batatas** (Sweet Potato) mature in six months after the cuttings are put out; they start in delicate strands from the base of the stem, and develop a few inches beyond it; average weight 10lbs. each. This is also called Vellary Avian (White boilable).

(*c*) *Chovalay Avian* (Red boilable).—Leaf-stalks and stems light red; flowers common; roots small, light red, firmly attached to the stems; mature in one year; average weight 10lbs. each.

(*d*) *Curry Avian* (the Curry boilable).—Leaf-stalks and stems pale pink; delicate plants; usual height 4 feet; flowers common; roots light red, large; average weight 12lbs. each; mature after one year; mealy and wholesome.

(*e*) *Chánď Avian* (the Cow-dung boilable).—So called from the manure usually used in its cultivation. Leaf-stalks pale but red at extremities; stems red, usual height 8 feet; roots few, substance of root arranged in two zones—the outer firm and farinaceous, the inner soft, pulpy, and unfit for food; average weight 8lbs. each.

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(*f*) *Chenkomban* (the Red-stemmed).—A variety resembling the Cheenee Avian, but with the leaf-stalks and stems a bright scarlet.

(*g*) *Neduvengauden* (the Neduvengaud Tapioca).—So called from the district of that name in Travancore where it was first cultivated. Small race; leaf-stalks and stems pale pink; roots small but numerous; average weight 4lbs. each.

II.—*The Maravans, or dark races,* like the particular dark-skinned class of thieves of that name in the Tinnevelly District. These are all more or less nauseous:—

(*a*) *Olley Karim Maravan* (the Dark Maravan).—Leaf-stalks deep red; stems dark green with purple streaks below the attachment of the leaf-stalks on the stem; plants delicate, flowers rare; roots mature in one year, few, deep brown, slightly nauseous; they are very lightly attached to the stem; average weight 10lbs. each.

(*b*) *Nedvuáli-Kian Karim Maravan* (a race whose roots take as firm possession of soil as the tenacious claws of the Neduvalior Iguana lizard).—A much-branched race with stem and leaf-stalk like Olley Karim Maravan; flowers common; roots few, woody, and have to be boiled twice before the bitter principle is removed.

(*c*) *Ana Maravan* (the Giant Maravan).—Leaf-stalks and stems like those of (*a*) in colour, but the stems are tall, thick, and strong, being usually about 20 feet high; flowers rare; roots very large, average weight from 20 to 25 lbs. each, and take 15 months to mature; very nauseous, requiring to be boiled three times.

(*d*) *Kathelay Marachini* (Kath-elay, *i.e.*, bitter-leaved).—Leaf-stalks like those of (*a*); stems pale yellow streaked with red; flower common; roots small but numerous. The race was at one time largely cultivated, but it is now rare; nauseous like (*c*).

(*e*) *Koota Maravan* (the Dwarf Maravan).—Dwarfed, much-branched race, usually 2 or 2½ feet high; leaf-stalks and stems like those of Kathelay Marachini; roots lightly attached to the stem; very nauseous.

(*f*) *Ellavum Kappa* (Areca-like Potato).—Tall race like the Ana Maravan; stems and leaf-stalks dark red; roots thin and numerous, often 25 to the stem; flowers rare; very nauseous.

(*g*) *Avanakkum Kappa* (the Castor-oil plant-like Potato).—Dwarfed, much-branched race, 4 feet high; leaf-stalks red; stems greenish-ash-coloured; roots few, at most four, small; slightly nauseous.

(*h*) *Vellay Marachini* (the White Tapioca).—Leaf-stalks and stems pale green, tall, delicate, much-branched; usual height 25 feet;

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flowers rare ; roots brown, lightly attached to the stems ; most poisonous, the bitter principle being eliminated only after at least seven successive boilings ; race growing extinct, being sometimes cultivated in North Travancore.

(*i*) *Olaven.*—Delicate, rare ; stems small, 3 feet high, branched ; flowers common ; roots small, few ; slightly nauseous.

(*j*) *Kili Vakay* (the Parrot-green Tapioca).—Stems and leaf-stalks bright green ; leaves few and far apart ; usual height 10 feet ; flowers common ; roots large, few ; average weight 12lbs.; slightly nauseous.

Of these races, the most nauseous, it will be seen, are the *Vellay Marachini* and the *Kathelay*, both which, however, are the oldest cultivated, and are now becoming rare ; so that long cultivation has, in their cases done comparatively little towards improving the quality of their roots. When left to themselves, and especially under cover, all these races grow into tall and lanky plants, which in time assume the nature of climbers, many of which are often thirty feet high.

With regard to the position the Tapioca industry occupies in Travancore, it may be said to compare favourably with many another similar industry in that country. Much of it is exported, especially of late, and, judging from the increasingly extensive areas under it, the importance of Tapioca cultivation as a profitable industrial pursuit is coming to be realised every day. The Tapioca has long since established itself as an important and excellent article of diet with the Malayali, and the recent steady rise in price of rice bids fair to make it one of the first staple food-stuffs for him, if it is not that already.

The following correspondence on the subject may be given here :—

From E. C. Chisholm, Esq., Colachel, Madras, to George Watt, Esq., M.B., C.M., C.I.E., Reporter on Economic Products to the Government of India, Calcutta,—dated Colachel, the 24th March 1897.

I will be much obliged if you will kindly inform me whether there are any factories in India for turning out Tapioca flour such as exist in the Straits Settlements. If you can tell me if there is any export of the flour or dried roots I will be much obliged.

To the above the following reply was issued by the Reporter :—

To E. C. Chisholm, Esq., Colachel, Madras,—No. $\frac{8}{1}\frac{5}{5}\frac{4}{1}$, *dated 22nd-23rd April 1897.*

In reply to your letter dated the 24th March last, I have the honour to inform you that inquiries have been instituted regarding the information asked for by you on the subject of Tapioca.

On receipt of replies you will be communicated with again.

M. 216—30.

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As there is a large industry in Tapioca in Travancore, it would be better however were you to address the Madras Chamber of Commerce for particulars. I may also add that you will find a most instructive paper on Tapioca in Travancore in *The Indian Forester*, Vol. XXI., pages 290—296.

At the same time the following letter, No. 877, dated the 23rd April 1897, was issued to the Secretary, Bengal Chamber of Commerce, Calcutta,—a letter of the same tenour, No. 878, dated the 23rd April 1897, being forwarded to the Secretary, Chamber of Commerce, Bombay:—

I have the honour to enclose copy of a letter, dated the 24th March last, from a correspondent, on the subject of Tapioca.

I have to request the favour of your being so good as to furnish me with the desired particulars.

Apologising for the trouble given.

The replies received were as under:—

From John Marshall, Esq., Secretary, Chamber of Commerce, Bombay,—dated Bombay, the 29th April 1897.

I am directed to acknowledge the receipt of your letter No. 878—151 of the 23rd instant.

In reply, I am directed to inform you that, so far as this Chamber has been able to ascertain, there is no export of Tapioca Flour or Roots from Bombay, nor can I learn that there are any factories for the manufacture of Tapioca Flour in India.

From W. Parsons, Esq., Secretary, Bengal Chamber of Commerce,—No. 740—97, dated Calcutta, the 7th May 1897.

I have the honour to acknowledge receipt of your letter No. 877—151, dated 23rd April 1897, enclosing copy of a letter from a correspondent on the subject of Tapioca, and inquiring if I can furnish you with the desired particulars.

I have caused enquiries to be made in this connection, but regret that I have not been able to obtain any information with regard to the systematic cultivation or manufacture of Tapioca in India, other than what is contained in Vol. XXI. of 'The Indian Forester,' where at pages 290—296 will be found an article on "Tapioca Cultivation in Travancore," in which, however, no particulars as to export are given.

Conf. pp. 13-19.

G. I. C. P. O.—No. 1703 R. & A.—24-6-97—2,200—R. B.

(Agricultural, Series No. 20.)

THE

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1897—No. 5.

SILT DEPOSITS.

(CANAL SILT.)

[*Dictionary of Economic Products, Vol. I., Pt. III.*, S. 2204 a.]

THE VALUE OF SILT AS A MANURE.

A Note on some Experiments which have been made to test the Value of Canal Silt. By DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

Early in 1893, at the suggestion of Sir Edward Buck, experiments were commenced to test the manurial value of the silt which is generally carried on to the land by canal water.

2. It was first attempted to carry out the investigation as a field experiment. Fields were embanked and the canal water run on during the monsoon. A crop was then taken in the following cold weather from this as also from a contiguous field to which no canal water was applied during the monsoon.

The first field on which I attempted to make the experiment was one taken up, with the permission of the Superintendent of the Dun, by the Tahsildar. The soil was very stony and the bunds could not be made strong enough to withstand the pressure of the water. Three attempts were made, but each time the bunds broke and I had to give up the experiment on this land.

Concurrently with this I had availed myself of the offer of two native gentlemen, who had some land in the Eastern and Western Dun, respectively, to take up plots of their land, and in these cases I was successful. The canal water was run on rather later than I had wished, but still it was successfully applied.

The experiment was made at two places, one in the Western and the other in the Eastern Dun. The land in the Western Dun was divided into two plots, A and B. Plot A had an area of 797 square yards and received no canal water; Plot B had an area of 855 square yards, and was treated with canal water five times during the monsoon. Both plots were sown with oats at the rate of 8 seers per bigha or 74 lb per acre—Plot A on 15th October 1893 and Plot B on 21st

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October 1893. The outturn from these plots was: Plot A 335lb per acre, Plot B 388lb per acre. The land in the Eastern Dun was divided into three plots, A, B, and C.

	Area, square yards.	Treatment.	Grain, lb per acre.	Straw, lb per acre.
A	738	Unsilted.	597	1,279
B	830	Silted.	627	1,100
C	747	Unsilted.	635	1,237

Plot B was situated in the middle, between the other two plots. Canal water was applied to Plot B four times. They were all sown with wheat on 18th November 1893 at the rate of 8 seers per bigha or 74lb per acre,

Comparing the results, it will be seen that the produce of the "silted" plot in the Western Dun is somewhat larger than that of the plot which received no silt, but that the results obtained in the Eastern Dun are not concordant, the outturn of Plot B standing midway between that of the other two plots. The differences are, however, not very great in any case.

3. The experiments are not altogether free from certain difficulties in their execution, and a note of one or two of these may be added.

The first field taken up for the purpose of these experiments had to be abandoned, because the bunds would not stand the pressure of the water. The land was fairly light and stony similar to much of the land in the Dun, and it is just on such land that the greatest benefit from an application of silt would usually be experienced. It is, therefore, to be regretted that the bunds could not be made to withstand the water-pressure. But it is also to be noted that this difficulty would be equally experienced by the cultivators. If bunds are so weak that they cannot be fairly trusted to hold water, they only prove a source of risk to other crops which might be damaged by water flowing on to them. No doubt, too, the cost of keeping up bunds made of light soil would be considerable.

The land on which the two experiments were eventually successfully carried out was of a much stiffer description, and no difficulty was experienced in keeping the water in the "kiaries." The amount of silt in two samples of the canal water was 28 and 131 grains per gallon, respectively.

So far as I can estimate about 10lb of Phosphoric acid and 10lb of Nitrogen would be supplied per acre in the water from which the second sample was taken. This is not as much as would be taken out of the land by an ordinary crop of wheat, but would probably supply more than half the deficiency.

The amount of plant food is, therefore, not by any means considerable, and one could not in any case expect a very large increase of outturn from its application.

That it has an agricultural value there can be no doubt, and this is exemplified in the case of rice lands, which are annually treated with deposits of canal silt from the water used for irrigation. On the other hand, there are difficulties in carrying out the experiment on light land, which is just the description of soil which would be usually most benefited by an application of silt. Again, if the silt be supplied to heavy land, the benefit is proportionately small, and the increased outturn of grain could not be expected to be large. Consequently, it becomes doubtful if the method would show the real value of silt sufficiently accurately.

4. Owing to the difficulty of demonstrating the value of canal silt by means of such field experiments as the above, it was decided to test the question by means of the chemical analysis of the silt in known quantities of water, These multiplied into the quantity of water applied to the land, which is regularly estimated by the Irrigation Department, give the amount of fertilising matter per acre.

Accordingly samples of water have been regularly supplied, the silt weighed and the Nitrogen, Phosphoric acid and (in one series) the Potash determined in it.

The following reports embody the results obtained—

5. (Copy of a letter No. 197, dated 25th September 1895, from the Agricultural Chemist to the Government of India, to the Executive Engineer, Upper Division, Eastern Jumna Canal, Saharanpur.)

With reference to the canal water samples with which you have supplied me during the last year from the Upper Eastern Jumna Canal, I have now the honour to submit in the accompanying statements the results of the analysis and the deductions which may be drawn therefrom.

There are two samples for the months of June and July, respectively (1894 and 1895). In the case of that for June 1894, the sample was drawn after the commencement of the monsoon, whereas that for June 1895 was collected *before* the rains had set in. This will explain the wide difference which existed between the amounts of silt in these two samples. The amounts of silt in the two for July seem to agree fairly well.

It will also be seen that, as might have been anticipated, the quantity of silt decreases from the end of the rains throughout the hot weather.

There was not sufficient silt in each sample for the separate determination of Potash, Phosphoric acid and Nitrogen, but the silt of the different samples was collected and one complete analysis made. From this and the quantity of silt, together with the depth of water which was used on the land, the amount of each of these several plant foods, Potash, Phosphoric acid and Nitrogen which are carried on to the land at any season of the year, may be calculated.

The figures now submitted in Statement 2 must not, however, be

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considered as more than approximate. One analysis of silt is hardly enough to go upon, and for the quantity of water put on the land during the different seasons of the year, I have had to refer to the Irrigation Revenue Report for 1893, *i.e.*, the year previous to the one during which the samples have been calculated. But the figures in Statement 2 have nevertheless an approximate value, and probably indicate the extent to which canal silt on this particular canal is manuring the land.

STATEMENT No. 1.

Amount of Silt in the Water of the Upper Eastern Jumna Canal.

Sample No.	373/92-94.	381/92-94.	331/95.	385/92-94.	392/92-94.	397/92-94.	419/92-94.	168/95.	183/95.	212/95.
Date . .	21st June 1894.	17th July 1894.	10th July 1895.	8th August 1894.	29th September 1894.	17th October 1894.	5th December 1894.	3rd April 1895.	8th May 1895.	4th June 1895.
Parts of Silt per Million of Water	1,500	2,138	1,811	10,575	1,294	677	648	321	343	171

STATEMENT No. 2.

Amounts of Plant Food supplied per acre.

	Kharif.	Rabi.	Whole year.
	℔ per acre.	℔ per acre.	℔ per acre.
Potash	154	19·6	54·6
Phosphoric acid	42	5·2	15·0
Nitrogen	31	3·8	10·8

The crops principally irrigated by this canal at the different seasons are rice in the kharif, wheat in the rabi, whilst sugar-cane is the principal crop which occupies the land all the year round. The amounts of the plant foods supplied in the kharif are probably sufficient for the entire rice crop; but during the rabi they are not sufficient for the wheat, and the deficiency is probably still greater in the case of the sugar-cane.

I have had the advantage of personally discussing these results with Mr. Ward Smith, and he thinks that it would be well to carry out a similar and at the same time more complete set of analyses during the next twelve months. Since the three principal crops irrigated are rice, wheat and sugar-cane, the samples taken should have reference to the months during which the water is used for these three crops.

Then, too, the amount of water supplied to these crops can, he thinks, be estimated more exactly than by reference to the figures in the Irrigation Revenue Report. For example, "mean depth of water supplied during the kharif" has reference to the six months April-September, and is not the same as the depth used for rice. I need not enter further into this question, as you will be able to deal with it.

As to the samples of water, I will have 8 Winchester Quarts fitted up in two boxes, and these I will send to you. They should all be filled for each sample, and in this manner I shall be able to obtain sufficient silt to make the necessary chemical determinations. I would suggest, however, that the eight bottles might with advantage be filled at different hours during two or even four days, so as to allow for odd variations in the state of water.

The samples may be taken about once a month though, I dare say, an advantage would be gained if the dates for collecting them were fixed rather according to the particular crop which is being irrigated. For example, a sample taken early in June might have reference to the sugar-cane crop but not to the rice crop, whilst one taken at the end of June would have reference to the rice but not to the sugar-cane. This is, however, also a question which you can

better decide than I, and I will merely ask you to inform me what you would recommend to be done.

6. During July and September 1894 several samples of water were taken from the Bijapur canal, Dehra Dun, but the year was abnormally wet, and I understand from Mr. Dupuis that the amount of water taken for the rice was correspondingly low. I do not think that the results are worth quoting.

7. (Copy of a letter No. 190, dated 23rd July 1896, from the Agricultural Chemist to the Government of India, to the Executive Engineer, Upper Division, Eastern Jumna Canal, Saharanpur.)

With reference to the experimental determination of the value of canal silt, I have the honour to submit the results obtained by the analysis of the samples obtained last "rabi."

Owing to an accident the silt in the sample taken in February was destroyed.

It will be seen from the accompanying statement that, although there was less silt in the sample collected in April than in that collected in December, the amount of Nitrogen and Phosphoric acid per million parts of water afforded by the two samples did not differ very greatly. Since the February sample was lost, I have taken the mean of these two samples to represent the silt in the "rabi" season canal water. The amounts of Nitrogen and Phosphoric acid are very small, but since the rainfall generally was so light during the cold weather, it is probable that in an average year the proportions of these plant foods would be greater.

STATEMENT.

Sample No.	Date.	Parts of silt per million of water.	Nitrogen.	Phosphoric acid.
$\frac{2}{96}$	December 1895 .	167	·06012	·182
$\frac{244}{96}$	14th-18th April 1896	60	·077	·130
		Mean of the two samples.		
		113	·068	·156

The mean depth of water applied to the land was 2·59″ which is equivalent to 7,029,000℔ of water per acre.

Thus the amount of Nitrogen supplied by the silt was ·478℔ per acre and of Phosphoric acid 1·101℔.

8. The results of similar determinations of the value of silt on the same canal during the year 1896-97 are as follows. For the monsoon

period as illustrative of the amount of plant food supplied to the rice crop :—

Date of collection of sample.	Parts of Nitrogen in silt per million of water.	Parts of Phosphoric acid in silt per million of water.
29th June 1896	2·86	3·26
5th August 1896	1·23	1·63
8th September 1896 . . .	·24	·64
Mean depth of water supplied per acre 8·25 feet	1·44	1·84
Equivalent in ℔ per acre . .	32·6	41·7

For the sugar-cane crop.

Date of collection of sample.	Depth of water applied.	Parts of Nitrogen per million of water.	℔ of Nitrogen per acre.	Parts of Phosphoric acid per million of water.	℔ of Phosphoric acid per acre.
31st December 1896 . .	Jan. 6″ Feb. 6″	·060	·156	·182	·478
11th May 1896	April 6″ May 6″	·077	·202	·130	·340
29th June 1897	June 12″	2·86	7·50	3·26	8·54
8th September 1897 . .	Sept. 6″	·24	·315	·64	·839
Total amount of plant food supplied .	...	...	8·173	...	10·197

During the rabi season of 1896-97 the amount of silt was so small that it could not be analysed and may be considered *nil*.

It will thus be seen that the amount of silt and its content of Nitrogen and Phosphoric acid are but very small during the cold weather, and quite insufficient to replace the plant food taken from the soil by a crop of wheat. On the other hand, it would appear to be certain that the silt carried on to the land during the monsoon period contains very material quantities of these plant foods. They are probably fully sufficient to replenish the amounts of plant food which are taken from the land by the rice crop.

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(Medical and Chemical Series, No. 10.)
(Dyes and Tans.)

THE AGRICULTURAL LEDGER.

1897—No. 6.

MYRICA NAGI.

(KAIPHAL BARK.)

[*Dictionary of Economic Products, Vol.* V., M. 869-77.]

THE TINCTORIAL PROPERTIES OF KAIPHAL BARK AND AN ANALYSIS OF THE COLOURING PRINCIPLE.

By PROFESSOR JOHN JAMES HUMMEL *and* MR. ARTHUR GEORGE PERKIN. *With an Introduction by* MR. DAVID HOOPER.

INTRODUCTION.

India is naturally rich in dyeing agents, and those of acknowledged value have been in use for so many years that it would seem superfluous to suggest changes in the industry. The introduction of aniline dyes, on account of their cheapness and ease of application, have to some extent reduced the trade in raw and bulky colouring materials; but there are still many tints obtained by the dyer in this country which cannot be imitated by artificial means. The indigenous vegetable colours are derived from plants, which, if not wild, are easily cultivated, and the Native operator in outlying districts is quite satisfied with his crude methods of dyeing passed down through many generations.

The attention that has recently been paid by experts to the different coloured dye-stuffs of India has resulted, for the first time, in an attempt to classify these articles scientifically. Mr. (now Sir Thomas) Wardle, of Leek, and Professor Hummel, of Leeds, have experimented with the dyes with regard to their technical properties, while Dr. Schunck and Mr. A. G. Perkin have elucidated the subject by their analyses of the actual colouring principles found in the raw products. As far as the yellow dye-stuffs have been investigated by

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Messrs. Hummel and Perkin conjointly, there are those applied with the aid of mordants having a similar chemical composition, while others which are applied direct are related in their tinctorial power to the constitution of their active principles. The experiments have enabled the authors to pass an opinion on the value of the dye-stuffs in European commerce and to indicate the permanent or fugitive nature of the colours obtained from them.

One of the most interesting results of the enquiry has been the discovery of a bark possessing a rich yellow colouring matter, far superior to many well-known dye-stuffs. The bark in question is derived from **Myrica Nagi** and has hitherto been collected and used for its medicinal properties which are described in Sanskrit works of great antiquity. The drug is astringent in its properties and has been used for tanning. The only reference to its use as a dye is very vague, and its properties are not known among Native traders. In the following paragraphs we have placed together all the available information on this article concluding with the exhaustive analysis recently made of the bark in England.

Myrica Nagi is an evergreen, diœcious tree belonging to the MYRICACEÆ, a small natural order of plants placed between the URTICACEÆ and the CASUARINEÆ. It is met with in the sub-tropical Himálaya from the Ravi eastward, also in the Khasia Mountains, Sylhet and southwards to Singapore, and is distributed in the Malay Islands, China and Japan.

Some confusion has arisen from the fact that the tree has been variously named by botanists, but from a thorough examination of the genus by Sir J. D. Hooker, it has been decided that the following six names refer to one and the same species—the tree under consideration:—

Myrica esculenta, *Buch.-Ham.*
M. Farquhariana, *Wall.*
M. integrifolia, *Roxb.*
M. missionis, *Wall.*
M. rubra, *Sieb. et Zucc.*
M. sapida, *Wall.*

The English name of the tree is Box Myrtle. In China it is called *Yangmæ* and in Japan *Shibuki*. *Kaiphal* is the name applied in India both to the tree itself and to the bark or portion of the tree used by the Natives.

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The bark is collected in the Himálaya at altitudes of from 3,000 to 6,000 feet, and is occasionally exported in large quantities to the plains in the North-Western Provinces and other parts of India, in recent years to the extent of 50 tons per annum. In Bombay it is worth from 1 to 2 rupees per maund of 41℔.

The bark is used as a tan for fancy leather work, and according to Mr. W. Coldstream it is used in Sirmur in the Simla District for dyeing a peculiar pink. It is also employed in medicine and is kept in stock in most of the Native drug shops in Northern India. In Sanskrit works the bark is described as heating, stimulant, and useful in diseases supposed to be caused by deranged phlegm, such as catarrhal fever, cough and affections of the throat. Like most Eastern remedies the bark is usually prescribed in the form of a mixture with other stimulants, alteratives and aromatics. Dr. U. C. Dutt speaks of the powdered bark being simply used as a snuff for catarrh with headache. *Kaiphal* mixed with ginger, according to some doctors, is the best medicine for cholera. Hindus and Mahomedans use *kaiphal* in the present day as an astringent, carminative and tonic, and prescribe it for chronic cough, fever and piles. Mixed with vineger it strengthens the gums and cures toothache. It will be seen that it is used where astringents are required, and the dose is stated to be sixty grains of the powdered bark.

The astringent properties of this bark are not utilised in India only as they are recognised in Japan and America. In an article on a number of tanning materials used in Japan, Mr. J. Ishikawa (*Chemical News*, December 3, 1880, p. 275) gives the result of his analysis of *shibuki* bark, obtained from **Myrica rubra,** and shows that the specimens submitted to him contained from 11 to 14 per cent. of tannin.

An American species of **Myrica (M. asplenifolia,** *L.*) was examined in 1894 by Mr. C. C. Manger, who found the following maximum proportions of tannin in the moist state:—leaves, 9·42; stem, 3·72; rhizome, 5·47. In an absolutely dry state the proportions were as follows:—leaves, 10·28; stem, 4·16; rhizome, 6·00.

The bark of **Myrica Nagi,** when collected in India from large trees, is about half an inch thick, extremely scabrous, pitted from the separation of pieces of suber, of a mottled rusty brown and dirty-white colour, suber warty; substance of bark and inner surface

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of a dull red colour; it yields a red colour to water; taste strongly astringent. Examined miscroscopically, within the suberous layer is seen a remarkable stratum of stony cells; the parenchyma throughout is loaded with red colouring matter, and permeated with large laticiferous vessels, from which a gummy latex exudes when the bark is soaked in water. In a powdered condition it acts as an irritant on the mucous membrane of the nostrils.

A sample of *Kaiphal* from Bombay, consisting of thick pieces of bark, evidently taken from old trees, contained 11 per cent. of moisture and yielded 7 per cent. of ash. Estimated for tannin, it afforded 13·7 per cent. The lead compound of the tannic acid left when ignited 30·72 per cent. of oxide, a result which compared very closely with the amount found in the compound separated from the "kino," namely, 31·88 and 30·36 per cent. in two estimations. The tannic acid, separated from the tincture by evaporation and treatment with water, gives a bluish-purple colour with ferric chloride, but on adding this reagent to a decoction of the bark, a dirty green precipitate is formed.

Mr. H. R. Procter, Lecturer on Leather Industries, Yorkshire College, Leeds, gives the following average of four separate analyses of the bark of Myrica Nagi:—

Tannin matters absorbed by hide . . .	27·3
Soluble non-tanning substances . . .	7·9
Fibre, and insoluble matters	52·3
Moisture	12·5
	100·0

It will be observed that the variability in the amount of the tannin in these barks has a wide range. The sample examined in Leeds by Mr. Procter contained about double the amount of tannin to that purchased in the Bombay market. Like most of the astringent barks the richness of the active principle may be attributed to the age of the tree or portion of the tree, branch or stem, which afforded the sample.

In 1889, Dr. Dymock sent the writer for analysis a sample of Myrica Kino. This substance occurred in a granular condition; it was of a dark purplish-red colour, hard and brittle when dry, and without any peculiar odour. It dissolved almost completely in boiling water, but a flocculent red precipitate separated when the decoction cooled.

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A tincture made with rectified spirit was of a fine, bright red colour and very acid in reaction. The tannic acid gave a greenish colour with ferric chloride, and was estimated in a cold watery infusion of the drug with a solution of plumbic acetate. The "Kino" had the following composition:—

Pure tannic acid	60·8
Insoluble in water	3·3
Moisture	9·8
Ash	10·8
Sugar, etc.	15·3
	100·0

The large amount of carbonated ash left, on incineration, points to the probability of some of the tannic acid existing in combination with a mineral base, and this was really so. A large quantity of a substance readily reducing Fehling's test, is not a usual constituent of a natural astringent secretion like Kino, and it was interesting to find that the above substance had been prepared by evaporating a watery decoction of the bark; this would account for the presence of mineral matter and glucose in the extract.

For several years past Professor Hummel, of Leeds, has been working on the Dyes and Tans of India, and recently, in conjunction with Mr. A. G. Perkin, who has submitted each dye to a critical chemical analysis, a most valuable series of papers has been published on Indian dyeing materials.

In a letter dated the 22nd November 1894, Sir F. A. Abel, Bart., K.C.B., Secretary and Director of the Imperial Institute, communicated to Dr. Watt some of the results of these investigations, and referring to the labours of Professor Hummel he wrote: "He also informs me that he has completed preliminary dyeing experiments with the whole of the Indian dye-stuffs in the Museum of the Yorkshire College, and he sends me a list of eight which are sufficiently rich in colouring matter to render them worthy of examination both chemically and tinctorially in preference to others. He asks whether I can obtain for him within, say, a year from this time from 1 to 2 cwt. of three or four of these materials which he names in the order of their merit of dye-stuffs."

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In the list which Sir F. Abel appended to his letter and which specifies the dyes arranged in the order of their tinctorial value, it is seen that the bark of **Myrica Nagi** takes the highest place.

1. **Myrica Nagi** (bark).
2. **Delphinium Zalil** (flowers).
3. **Carpesium abrotanoides** (whole plant).
4. **Nyctanthes Arbor-tristis** (flower tubes).
5. **Kandelia Rheedii** (wood).
6. **Gossypium herbaceum** (flowers).
7. **Thespesia populnea** (flowers).
8. **Mangifera indica** (bark).

The Reporter on Economic Products to the Government of India having supplied the required quantity of Kaiphal bark next year Messrs. Hummel and Perkin published the results of their work in this direction as far as they had gone. The paper was read before the Society of Chemical Industry, London, and printed in the Journal for May 31, 1895. It was sent as a contribution from the Clothworkers' Research Laboratory in the Dyeing Department of the Yorkshire College, Leeds, and was entitled "The Tinctorial Properties of some Indian Dye-stuffs, Part II." The following extract gives the conclusions the authors arrive at with regard to **Myrica** :—

"The dyeing properties of **Myrica** bark, although generally similar to those of other yellow mordant dye-stuffs, differ in some respects from any one of them. On wool, with chromium mordant, it gives a deep olive-yellow, and with aluminium a dull yellow, similar to the corresponding colours obtained from quercitron bark, but much fuller; with tin mordant, however, it gives a bright red-orange, redder in hue than that given by quercitron bark, and fuller even than that given by an equal percentage of Persian berries, to which otherwise it is very similar; with iron mordant it gives a dark greenish-olive like that obtained from quercitron bark, but again fuller; it seems indeed to have a greater colouring power than all other natural yellow mordant dye-stuffs.

"On cotton with aluminium and iron mordants it dyes colours which are more similar to those obtained from old fustic than from quercitron bark, the colours with iron mordant, for example, not exhibiting the dark and bluish hue given by the latter, as though tannin matter were absent.

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" Compared with old fustic, on wool mordanted with aluminium, 3·7 grms. **Myrica** bark equal in dyeing power 5 grms. old fustic but it gives a much duller olive-yellow colour. Compared with Chromium mordant on wool, 2 grms. **Myrica** bark are equal to 5 grms. old fustic, but here, too, the colour is much redder or browner.

" The comparative richness in colouring power of **Myrica** bark, and the full, brilliant red-orange given with tin mordants on wool, are sufficiently interesting to warrant us in examining this bark thoroughly, more particularly since it is evident that its utility as a dye-stuff is unknown to the Hindus."

Sir F. A. Abel, when forwarding copies of the above paper from the Imperial Institute, on the 27th June 1895, made a request for a larger supply of the bark to allow of a complete set of experiments being carried out, and in accordance with the request about 70℔ of Kaiphal were collected by the Reporter on Economic Products in Simla and despatched to London in November.

In the course of a few months the following important paper on a full analysis of Kaiphal appeared in *The Transactions of the Chemical Society.* The paper is printed *in extenso*, with the exception of the experimental data and calculations of the formulæ :—

Contribution from the Clothworkers' Research Laboratory, Dyeing Department, Yorkshire College. The colouring principle contained in the bark of Myrica Nagi. *Part I.*

By ARTHUR GEORGE PERKIN and JOHN JAMES HUMMEL.

In the course of examining the tinctorial properties of some Indian dye-stuffs (*J. Soc. Chem. Ind., 1895*) our attention was especially attracted by the behaviour of the bark of **Myrica Nagi.** Not only did the colouring power compare favourably with that of such well-known dye-stuffs as old fustic and quercitron bark, but in some respects it seemed to differ from all other yellow mordant dye-stuffs. Having subsequently received a larger supply through the kindness of the authorities of the Imperial Institute, London, the chemical examination of this dye-stuff was undertaken, and the results are recorded below.

EXPERIMENTAL PART.

The ground bark (1,000 grams) was digested for six hours with ten times its weight of boiling water, the mixture strained through

calio, and the residue treated again in a similar manner. Experiment showed that by extracting the filtrate with ether a small amount of colouring matter could be thus obtained; the ethereal extract separated, however, with difficulty from the aqueous liquid, and as also a very large quantity of ether was necessary for this process, the following method appeared preferable. To the combined boiling aqueous extracts, a solution of 60 grams of lead acetate was added, when a bulky, yellowish precipitate was obtained, which, on prolonged boiling, became dirty white; this consisted almost entirely of the lead compound of tannin matter, and contained but a trace of colouring matter. This was removed by filtration, washed with water, and the filtrate treated with more lead acetate solution until a precipitate was no longer formed; the lemon-yellow lead compound was then collected, washed, and decomposed, while still moist, by means of boiling dilute sulphuric acid. The brown liquid, which now contained the colouring matter, was removed from the lead sulphate by decantation, and extracted twice with ether; the yellow crystalline residue left on evaporating the ethereal extract was dissolved in a little alcohol, and the solution diluted with boiling water. The crystals which separated on cooling, were collected and extracted two or three times with small quantities of boiling acetic acid in order to remove a colourless wax-like substance which was present in some quantity. By recrystallisation from dilute alcohol, the product was obtained in a pure condition. The yield of colouring matter from 100 grams of bark averaged from 0·23 to 0·27 gram.

The ultimate analysis indicated the formula $C_{15}H_{10}O_8$, which requires $C = 56{\cdot}60$; $H = 3{\cdot}14$ per cent.

It formed a mass of light yellow, glistening needles closely resembling quercetin in appearance, and melting above 300° with decomposition. When heated between watch glasses, the mass became carbonised, and a small quantity of yellow vapour was evolved, which, on cooling, condensed to minute needles of the unchanged substance. It is very sparingly soluble in boiling water, somewhat readily in alcohol, and almost insoluble in chloroform and acetic acid. Though closely resembling in appearance the colouring matters of the quercetin group, it is readily distinguished from those at present known by the colour changes it produces when dissolved in alkaline solutions. With dilute potassium hydroxide, a green solution is first

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formed; this, on exposure to air, rapidly assumes a deep blue tint, which in its turn gradually becomes dull red-violet. With strong alkali a fairly permanent orange-coloured liquid is obtained which, when diluted, passes through the colour changes recorded above. A solution of ammonia produced somewhat similar results, the colour obtained having, however, a redder tint. The addition of lead acetate to its alcoholic solution throws down a reddish-orange precipitate which becomes yellower on boiling. The colouring matter dissolves in cold sulphuric acid, forming a deep red solution, which deposits the unchanged substance on adding water. Its alcoholic solution is coloured brownish-black by ferric chloride. In examining the dyeing properties of this new colouring matter, for which we propose the name *myricetin*, experiments were carried out with it side by side with equal weights of pure preparations of quercetin, fisetin, morin, gentisin, and euxanthone, using woollen cloth mordanted with chromium, aluminium, and tin. It was at once apparent that a strong resemblance existed between the shades given by myricetin, quercetin, and fisetin, in fact, so similar were they, that unless placed side by side one might easily be mistaken for the other. These differences are best seen in the table.

This table shows that, so far as its dyeing properties are concerned, morin belongs to a distinct group, and the same may be said regarding gentisin and euxanthone.

By examination in Zlesel's apparatus, myricetin was found to contain no methoxyl-groups.

		Chromium.	Aluminium.	Tin.
1	Myricetin .	Red-brown .	Brown-orange . .	Bright red-orange.
	Fisetin .	,, .	Brown-orange, inclining to red.	Slightly less red.
	Quercetin .	,, .	Brown-orange, inclining to yellow.	Bright orange.
2	Morin .	Olive-yellow .	Dull yellow . .	Bright yellow.
3	Gentisin .	Green yellow, dull and pale.	Bright yellow tint, very pale, scarcely dyed.	Cream colour, scarcely dyed.
	,, .			
	Euxanthone	Dull brown, yellow.	Bright yellow, pale.	Bright yellow, tint very pale, scarcely dyed.

Myricetin Sulphate, $C_{15}H_{10}O_8,H_2SO_4$.—In order to determine the molecular weight of myricetin, its behaviour towards mineral

acids was studied, this method, as shown in former communications having proved of considerable service for this purpose.

The addition of sulphuric acid to myricetin suspended in boiling acetic acid caused the formation of an orange-coloured, crystalline compound, which was collected, washed with acetic acid, and dried.

It was obtained as a glistening mass of slender needles somewhat redder than the corresponding quercetin compound. By treatment with water, it is decomposed into myricetin and sulphuric acid.

Myricetin hydrobromide, $C_{15}H_{10}O_8,HBr$ is obtained in orange-red needles on adding hydrobromic acid to myricetin suspended in boiling acetic acid.

By treatment with water, it is decomposed into myricetin and hydrobromic acid.

Myricetin hydrochloride, $C_{15}H_{10}O_8,HCl$, closely resembles the above compound. When heated at 100°, it is slowly decomposed into myricetin and hydrochloric acid, and was consequently not analysed. In the instability of its compound with hydrogen chloride, myricetin resembles quercetin, fisetin, and morin (*Trans.* 1895, 67,646), but differs from that of luteolin (this vol., p. 208), which is stable at this temperature.

Myricetin hydriodide, $C_{15}H_{10}O_8,HI$, crystallises beautifully in glistening needles of a red orange colour. The above results show that the true formula of myricetin is $C_{15}H_{10}O_8$.

Hexacetylmyricetin, $C_{15}H_4O_8(C_2H_3O)_6$.—A solution of one part of myricetin and one part of anhydrous sodium acetate in three parts of acetic anhydride was boiled for one hour, the product poured into water, and, after being allowed to stand 24 hours, collected and purified by crystallisation from alcohol.

It forms a silky mass of colourless needles melting at 203—204° very sparingly soluble in alcohol, more readily in acetic acid. It is insoluble in cold alkaline solutions. In order to determine the number of acetyl groups present in this substance, a solution in acetic acid was boiled with the addition of a few drops of sulphuric acid. Boiling water was then added, and the crystals of myricetin which separated on cooling were collected and weighed, and from an ultimate analysis the substance was proved to be a *hexacetyl* compound.

Hexabenzoylmyricetin, $C_{15}H_4O_8(C_7H_5O)_6$.—Owing to the readiness with which myricetin decomposes in alkaline solution, the method of Baumann and Schotten was not available. Myricetin was therefore heated with excess of benzoic anhydride at 160—170° for four hours, and the product dissolved in acetic acid and poured into alcohol. After 12 hours, a colourless precipitate had separated, which was collected, washed with alcohol, and purified by crystallisation from this solvent.

It was obtained as colourless needles, readily soluble in acetic acid, sparingly in alcohol.

Action of Fused Alkalis on Myricetin.—Myricetin was heated with ten times its weight of potassium hydroxide at 150—170° until the melt, which was originally of an orange colour, had become brown. It was then dissolved in water, the solution neutralised with acid, extracted with ether, the extract evaporated, and the crystalline residue dissolved in a little hot water. On adding lead acetate, a yellowish-white precipitate was formed, which was collected, and washed with hot water, the filtrate being placed aside for further examination.

The lead precipitate, suspended in a little water, was decomposed by sulphuric acid, the lead sulphate removed by filtration, the filtrate extracted with ether, and the extract evaporated. The brown residue, which became crystalline on standing, was treated with a very little hot water, in which most of it dissolved, the small quantity of insoluble product being collected. This, on examination, was found to be a trace of unaltered myricetin, and it is strange that any of this substance, which is so readily decomposed in dilute alkaline solution, should have resisted the action of concentrated alkali at such a high temperature.

The filtrate, on standing, deposited crystals, which after being drained upon a porous tile and crystallised two or three times from boiling water, formed a mass of needles of a slightly brown tint, melting at 239—240°, with evolution of gas, and giving the reactions of gallic acid with ferric chloride. As, however, the reactions of phloroglucinolcarboxylic acid are very similar, according to Will and Albrecht (*Ber.*, 1884, **17**, 2103; 1885, **18**, 1323), it was necessary to institute further tests. It was found that the substances dyed iron mordanted calico like gallic acid, that it did not give with fir wood

and hydrochloric acid the phloroglucinol reaction, and, further, that when heated to 240° the residue had the properties of pyrogallol, and not of phloroglucinol. It was therefore *gallic acid.*

The filtrate from the lead precipitate was treated with sulphuric acid to decompose lead compounds, the lead sulphate removed by filtration, the filtrate extracted with ether, and the extract evaporated. The residue thus obtained was too small for complete purification, but it gave the phloroglucinol reaction, and without doubt consisted chiefly of this substance.

The principal products of the action of fused alkali on myricetin are therefore *gallic acid* and phloroglucinol.

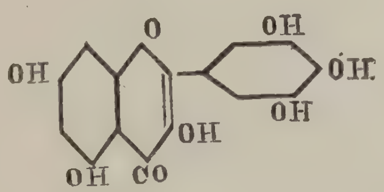
Action of Bromine on Myricetin.—To a thin paste of myricetin in acetic acid, the amount of bromine necessary for the formation of a tetrabromo-compound was added. Hydrogen bromide was evolved, and a clear solution gradually formed; this, after standing over night, was poured into about six times its bulk of water. At first crystals were slowly deposited, but after some time a small quantity of flocculent matter also separated. The product was collected and purified by several crystallisations from dilute acetic acid. As the yield obtained in this way was somewhat unsatisfactory, experiments were carried out on the bromination of myricetin suspended in carbon bisulphide at 100°. By these means the quantity of product obtained was found to be considerably increased.

It was obtained in the form of brownish-orange, prismatic needles, melting and decomposing at 235—240°, readily soluble in acetic acid, slightly less so in alcohol. Alkaline solutions dissolve it at first with a yellow colouration, which on exposure to air becomes red, and finally passes into dirty brown. Its alcoholic solution gives with ferric chloride a deep blue colouration. With mordanted calico, it dyes shades considerably yellower than those of myricetin itself, and more resembling those yielded by gallacetophenone.

Although the analytical numbers agree closely with those required by tetrabromomyricetin $C_{15}H_6O_8Br_4$, and moreover the production of such a compound is in harmony with the probable constitution of this substance, yet on account of the peculiarity of its properties considered side by side with those of the bromine derivatives of quercetin, morin, and luteolin, some little doubt must be entertained

as to its identity until a molecular weight determination can be carried out. By the introduction of bromine into the above colouring matters, their reactions with ferric chloride are but little altered; moreover, these compounds are considerably less soluble than the colouring matters themselves.

In examining the results of this investigation, but little doubt can be entertained that myricetin is a member of the quercetin series. Its formula, its reactions with mineral acids, and the number of hydroxyl groups it contains, when considered with the results of its decomposition with alkali, are all in harmony with this suggestion. Moreover, its dyeing properties are very similar to those of quercetin and fisetin. Before absolutely deciding its constitution, it will be necessary to examine its methyl and ethyl ethers and their decomposition products; unfortunately, the difficulty of isolating sufficient substance for this purpose may delay this investigation for some time. There appears, however, every probability that myricetin, $C_{15}H_{10}O_8$, will thus be shown to have the constitution of an hydroxy quercetin,—



Its colour reactions in alkaline solution are evidently due to the oxidation of the pyrogallol nucleus it contains.

Dyeing Properties.—The tinctorial power of the product now examined was much less than that of the small sample of bark with which the earlier experiments were made, and which had a much smoother exterior, and was labelled **Myrica rubra**; moreover, it gave somewhat different shades with the different mordants. On striped mordanted calico, the present sample gave with alumina a comparatively dull yellow, inclining to pink on a weak mordant, and with iron a purplish-grey, as if tannic acid were present. Its colouring power was much less than that of old fustic and quercitron bark. On the other hand, our former sample gave with alumina a

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full yellow, distinctly stronger, although somewhat duller, than those given by the dyewoods just mentioned, and the colour with iron mordant gave little or no indications of the presence of tannic acid. On wool mordanted with chromium, aluminium, and tin, and dyed with 40 per cent. of our latest sample, greenish-olive, olive-yellow, and yellow colours respectively were obtained, all very pale and dull, whereas with the same mordants our former sample yielded deep olive-yellow, dull-yellow, and bright red-orange, the two first reminding one of the corresponding colours obtained from quercitron bark, the latter being very similar to those given by Persian berries.

These results show either that the colouring properties of **Myrica Nagi** are somewhat variable, according to the age of the tree or branch from which the bark is taken, or that there may be different species of **Myrica,** each with slightly different tinctorial properties. The comparative richness of some of the barks, however, warrants us in directing the attention of native dyers of India to its probable utility as a yellow dye-stuff.

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(Mineral and Metallic Series, No. 9.)

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REH.

[*Dictionary of Economic Products, Vol. VI., Pt. I., pp. 400—426* R. 67-70]

RECLAMATION OF REH OR USAR LAND.

Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India on certain experiments which have been carried out for that purpose.*

1. ***Area.***—The Usar Plains of Northern India are so very extensive and allow of such poor cultivation within their area, that they constitute a source of serious anxiety to Government, especially to the Government of the North-Western Provinces and Oudh within which territory the evil is of the most pressing description.

The area of these plains in the North-Western Provinces and Oudh amounted to 3,129,053 acres in 1888 (*vide* letter No. 1247 of 28th July 1888 from the Director, Land Records and Agriculture, North-Western Provinces, to the Secretary to the Board of Revenue, North-Western Provinces).

2. A considerable amount of time has been spent by several observers with the object of determining one or another factor in relation to this subject, and a number of experiments have been made with a view to determining some practical means of getting rid of these salts and so making the land culturable.

A short description of these forms the subject of the present Note.

3. ***Cause of Sterility.***—The sterility of these plains is due to the presence of certain salts, principally Sodium carbonate, Sodium sulphate and Sodium chloride, in the soil, the last named, however, being usually in subordinate amount.

4. ***Amount of Salt in the Soil.***—The extent to which these salts are concentrated in the soil varies within considerable limits. Some "Usar" land has no visible sign of salt in it and analysis of the surface soil will show it to contain from 0·1 to 0·4 parts of salts per 100 parts of dry soil. In other places, and there are large areas of such, the salt lies on the surface of the ground, an inch or more thick. As, however, is natural with salt which has effloresced in this manner, it lies very light, and if scraped up, it will be found to be mixed with a proportion of earth.

The best test as to its amount in the surface soil is afforded by the determination of the amount of salt in a sample of the earth taken to a definite depth.

The following determinations by chemical analysis have been made of the amounts of salt in earth which was covered with Reh.

Mr. Medlicott, Director, Geological Surveys, found in a sample of surface soil, 3 inches deep, and which was covered "with a thick crust of Reh," 1·88 per cent. of salt; at 2 feet from the surface 0·24 per cent.; and at 6 feet 0·15 per cent.

Mr. Ward, Royal School of Mines, London, found in a surface soil 3·12 per cent.; at 2 feet 0·37; at 4 feet 0·51.

5. ***Origin of the Salts.***—The salts can only originate in four possible ways: (*a*) from a sub-soil bed of salt; (*b*) they may have been brought at least in part by the rivers when the alluvium of the plains was deposited; (*c*) they may be simply those portions of the soil which have been rendered soluble by water, air and plants and rejected by the latter and which have not drained away; (*d*) they may have been brought in part in the canal water used for irrigation.

(*a*) As to the supposition of a definite bed of salt, there is only negative evidence; in those few deep borings which have been made in the alluvium of North-Western India no salt was found (*vide* Manual of Geology, page 432, *et seq.*).

(*b*) Dr. Center has suggested, that the salts which are dissolved from the rocks and brought down by all rivers, may have been a source of the salt accumulations under notice, that indeed as the alluvium became deposited, the river water left some salt behind.

(*c*) The third source of these salt accumulations which was first accounted for by Mr. Medlicott and afterwards also by Dr. Center is the soil itself. As Mr. Medlicott pointed out in his Note to the

Reh Committee, which sat in 1878, it is perfectly well known that by the action of the Carbonic acid and moisture of the atmosphere, aided by the sun's heat, the rocky particles of the soil become decomposed and reduced to simpler compounds; similar effects are produced by the roots of plants. Thus Silicates of soda, potash, lime, etc., are decomposed, and the "bases" named become converted, at least primarily, into carbonates. In the event of the land being covered by vegetation, the plants take up, *i.e.*, feed on, lime and potash, but reject for the most part the soda. Hence in all ordinary soils there is continually set free a quantity of sodium-salt, unused by the plant, and it ordinarily passes away with the drainage water.

Touching this Mr. Medlicott says, in paragraph 2 of his Note to the Reh Committee:—

"Reh is formed of highly soluble sodium-salts, the result of the decomposition, by air and water, of the particles of rock minerals to be found in almost every soil; and thus reh itself occurs very generally in soils, being the waste products of soil-formation—the elements unassimilated by vegetation—the gradual removal of which is (or should be) effected by the rain water draining through the soil and carrying with it any excess of these highly soluble salts. In this way all sub-soil drainage water contains Reh, while mere surface drainage water contains little or none, but only matter in mechanical suspension; and thus it is that rivers in flood contain less dissolved matter than in dry weather, when fed chiefly by percolation water."

(*d*) A fourth cause has been suggested, namely, that Reh has been brought on to the land in the canal water. Mr. Medlicott says in paragraph 3 of his Note (already alluded to):—

"The fact last mentioned points to another important factor of the problem before the Committee; that canal water, being, to some extent, sub-soil drainage water, must contain reh; and that it does so has been pointed out by every one who has analysed the water with reference to this question; by Dr. O'Shaughnessy in 1850, by myself in 1861, and by Mr. Ward in 1869. The importance of this factor will be apparent when the other conditions of reh-formation are considered, and the persistent denial of it by canal officers is an infatuation."

And again in paragraph 10 Mr. Medlicott says:— "............they (the canals) have unquestionably introduced an independent and an inexhaustible source of Reh."

And after referring to the importance of the fact of the rise in the sub-soil water level, he continues:—

"............ but it is quite evident that where the conditions of *reh*-formation are set up, *i.e.*, where the removal of soakage water takes place

almost exclusively by evaporation, irrigation by canal water must end in a destructive crop of reh, where the indigenous resources of the ground in that way were comparatively harmless. The process may be slow, according to circumstances, but that it is certain, no man in his senses will deny."

Mr. Ward, Royal School of Mines, also writes, in his report on some samples of soils and water which were submitted to him—

"With regard to the first cause suggested, *viz.*, the canal water, it is certain that the continual irrigation of land with water containing sulphates and chlorides, which the canal water has been shown to contain, and the removal of which water is entirely due to evaporation, would inevitably have the effect of producing a reh soil in a time proportionate to the quantity of water applied—the only countervailing influence being the amount of alkalies removed in the crops. This is a very important point, the force of which is greatly augmented, if the composition of the Jumna canal water be really such as it is represented to be by the partial analysis given in this report; but it is manifestly useless to enter into any calculation on the subject without knowing anything of the quantity of water annually applied in irrigation, or with results obtained from specimens of water, the genuineness of which seems to need confirmation."

6. ***Causes of Accumulation of Reh.***—If, therefore, the cause of the origin of Reh as explained by Mr. Medlicott be accepted, the next question is: "If these salts of sodium are usually liberated in agricultural soils, why do they accumulate in this particular part of India?"

Imperfect Drainage.

(*a*) Mr. Medlicott (paragraph 8 of his Note to the Reh Committee) says:—

"................. I know of no cases of Reh that may not be due to the primary conditions already indicated which may be comprehensively expressed as *defective water circulation*. From the farmer's point of view it would be desirable to pass all the rainfall through the ground.................... Owing to shallow cultivation and a total absence of forest vegetation, the rain falls on a bare, hard, impervious surface; so far as the slopes admit, it runs off rapidly to the natural drainage courses, but much of it remains covering shallow depressions with great sheets of water. Although the ground is parched after the fierce heat of the early summer, comparatively little of this surface water is absorbed, quite insufficient to cause the needful partial escape by underground drainage, and so it remains to be withdrawn by evaporation leaving all the soluble matter at or near the surface."

Two other points, relating to the *accumulation* of Reh must now be referred to.

(*b*) In 1874 Mr. (now Sir) E. C. Buck brought to the notice of Government, the extent to which these salts were being carried by surface wash from one place to another. As explained by him, the first rain falling on the baked surface of the earth dissolves the salt which has effloresced and that portion of the water which does not immediately soak into the ground, carries with it the salt it has dissolved, and he gave instances of this surface wash having found its way from the usar plains into cultivated fields which were in consequence destroyed. **Surface washing.**

(*c*) Another cause of the accumulation of Reh is the wind. The salt lies lightly on the surface of the land and at the time of the monsoon wind, salt is carried in clouds before it. As Sir E. C. Buck in his Note to the Reh Committee says:— **Wind Drift.**

"...... for Reh, thick as driven snow, lies concentrated on the surface at the mercy, not only of water, but also of air, which, when the fierce and scorching west winds scour the plains, is lifted in thick clouds into the atmosphere and rolled in whirling columns over the adjacent country."

Also in a Note by Mr. F. N. Wright on the same subject, the effect of wind drift is thus described:—

"The villagers attribute considerable influence to the wind as an agent for propagating the mischief. In the hot months, they say, the wind blowing over places covered with this light impalpable efflorescence becomes laden with clouds of it (like a snow-storm with us, a dust-storm with them), and deposits its burden on the fields first reached, and thus commences the mischief. Of the truth of this assertion there can be no doubt, so far as it goes, for fields to the east of usar plains are invariably attacked on their western-most edge."

7. ***The Effect of the Canals.***—The more serious effects of Reh were experienced a few years after the introduction of the canal system, and as a somewhat natural consequence to them was attributed by many the whole of the blame.

(*a*) Several reasons were advanced for condemning these artificial watercourses. One was that they had been badly aligned and had interfered with the natural drainage of the country. So far as this is concerned, the cause has been recognised and every endeavour made to open up, either by re-alignment or by water sluices, the natural drainage of the country. **Bad alignment.**

(*b*) Another serious complaint against the canals was that the level of the sub-soil water was raised, owing partly to leakage through the bottom of the canal and partly to the large amount of irrigation which **Canals raised the water level.**

was thus suddenly introduced. Mr. F. N. Wright, writing in reference to this point in 1878, says :—

"There is not the least doubt of the great rise in the water level in the vicinity of the canal. Not only is the normal level according to my experience about 20 to 25 feet in such a tract, whilst here (Aligarh District?) it is 6 to 12 feet, but the old bullock runs show it to have been much further below the surface formerly, and the levels I took as I receded from the canal lead to the same conclusion."

The evidence of cultivators and zemindars leads to the same conclusion, and there would appear to be little doubt that the level of the sub-soil water has been raised, until it is in many places only five or six feet from the surface. Mr. Medlicott suggests in his note above alluded to, that prior to the introduction of the canals, an almost permanent equilibrium had been established, that, although the natural drainage of this land is bad, the salts had accumulated in the underground water, which was for the most part probably out of reach of capillary action. When, however, the level of this water was raised capillarity rapidly commenced and the salts which travelled up through the soil with the water, were left on the surface as that water became dissipated.

8. ***Experiments for the Reclamation of Usar Lands.***—In 1870 a Conference was held at Aligarh at which the several bearings of the subject of Usar land were discussed, and at which it was determined to commence a series of experiments for the determination of several of the factors related to the subject, and for the reclamation of these lands. The following experiments and observations were made :—

Reh Maps.

(*a*) Reh maps were prepared to ascertain the distribution of reh throughout the Provinces, and to study the variations through a series of years of the reh area in certain selected villages. The former has been prepared, and the latter observations were made in 65 villages of Pargana Akrabad of the Aligarh District over a series of years.

Surface Drainage Map.

(*b*) A surface drainage map was also prepared for the same villages of Akrabad.

Sub-soil Water Map.

(*c*) A survey of sub-soil waters showing the distance from the surface of the water in the wells, for the whole of the provinces.

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(*d*) *Agricultural experiments.*—A number of experiments of an agricultural nature were commenced at Awargarh, at Aligarh and at Cawnpur.

Effect of Surface Drainage.

(*e*) The effect of surface drainage was tested by throwing up low embankments and allowing the rain water to wash them. The experiment appears to have been a failure.

Sub-soil Drainage.

(*f*) Another plot of land was drained with two-inch pipes, but they silted up and this experiment was also fruitless.

Scraping Reh off the Surface.

(*g*) Similarly scraping the reh off the surface proved quite useless.

Tree Planting.

Other experiments have been more encouraging. One of the earliest experiments in the reclamation of usar land was commenced near Aligarh, where an area of about 24 acres, bordering on the Ganges Canal, was enclosed and planted with trees.

(*h*) The following extract from the Report, 1879, of Mr. Greig, Conservator of Forests, describes it:—

"The plantation is situated on the left bank of the Cawnpur Branch. It is bounded on the south by the Sikandra Rao rajbaha, and on the other sides by the Purdilnagar usar plain; on three sides it is fenced by a bank and ditch, the rajbaha forming the fence on the south side. The bank and ditch are not in good repair, and probably cattle enter the plantation occasionally, but I did not observe much sign of grazing. The plantation was formed in June and July 1874. Beds 3 feet in diameter at top, 2 feet at bottom, and 3 feet deep, were dug at 10 feet intervals, they were filled with good soil or silt and raised to a higher level than the natural surface. Of the 3,937 beds thus prepared, 238 were sown with *babul* seed, in the remaining 3,699 trees of various kinds (but no *babul*) were planted, and a few *babul* seeds were sown around the transplants. During the rains of 1874, coarse grass was planted between the trees in lines one foot apart.

From November 1874 to the commencement of the rainy season of 1875, the plantation was flooded with canal water about twice a month, but judging from the file, it has not been irrigated since June 1875. The total expenditure on the 10 acres up to date is put down at R489, about half of which was the cost of preparing the beds. I estimated that about four-fifths of the plantation is fully stocked with a fine crop of healthy *babul* trees of from 10 to 20 feet in height, with an occasional *sissu* and *sirus* growing in the midst of five or six *babul*, and sometimes towering above them. . . . . The well-stocked portions are chiefly on the north side of the plantation, towards the Purdilnagar usar plain. The remainder of the plantation, say, one-fifth, is either insufficiently stocked, or entirely devoid of trees, or planted with unsuitable trees, such

as Jawan, willows, etc. The vacancies are principally towards the south side, and, as a rule, they are in low-lying land where water lodges after heavy rain, in fact I feel sure that the failures are almost entirely caused by want of drainage, and are not in any way attributable to reh. There is a luxuriant growth of grass over almost the whole of the plantation in some places 2 feet high ; the reh only appears here and there in small patches, and these generally show signs of becoming covered with grass. The following is the treatment I recommend for the plantation :—

(*a*) "Where a healthy *sissu* tree is growing amongst a clump of *babul*, clear away the *babul* to encourage the *sissu* ; where a *sissu* or other tree is found in a clump of healthy *babul*, cut out the *sissu*, etc., to encourage the *babul*. No other thinning should be made at present, the object being to shade the ground and keep it cool, and thus encourage the growth of grass and the deposit of vegetable mould. In three or four years it will probably be necessary to do some thinning, but I hope to see the plantation again before them.

(*b*) "In the strip of low-lying land in which the principal vacancies occur, ditches should be dug at 10 feet intervals along the edges of the beds to form both drains and irrigation channels. The beds should be well dug up, and more good soil added to raise them a foot above the natural level of the land, they should then be sown with *babul* seed and kept damp but never flooded. All the other blank beds or beds in which there are sickly Jawan or other trees, should also be dug up and raised, and sown with the *babul* seed about the middle of June. It will probably be cheaper to hand-water these than to irrigate them, or the system of sub-surface watering, by *ghurras* sunk in the ground, might be tried.

(*c*) "Every endeavour should be made to exclude cattle ; the ditch should be dug and the bank repaired, and then agave planted. When planting the agave here it may perhaps be advisable to give each plant a little good soil to start it."

In December 1886, however, the reports were not so encouraging. Mr. Bagshaw, Officiating Conservator of Forests, states that all the larger trees, 20 to 25 feet in height, were gradually dying, many being already quite dead, the younger or trees of less advanced growth, still looked healthy.

Trees have been planted at several other places at Cawnpur and Aligarh. At Juhi near Cawnpur, a large number of *babul*, *dhak*, *ber*, *nim*, *shisham*, *pipal*, *bargad* and other hardy indigenous trees as well as a number of exotic plants, such as the salt-bush, sheep-bush, rain tree, have been planted from time to time after the following

methods; on slightly elevated spots, on sides of mounds artificially raised, and in pits.

Some of the pits were five feet deep, lined with "Willesden" rot-proof paper and filled with good soil from cultivated ground, whilst in other cases they were neither lined with the paper nor filled with new soil, the same soil being thrown back into the hole. Although success has not attended the planting of all the trees which were planted, still the land is now fairly well stocked. The same remarks are applicable to the plantations at Aligarh.

Effect of Canal Silt.

(*i*) On the Etawa Branch of the Ganges Canal 40 acres of usar land were taken in hand in 1873 and flooded with silt-laden canal water and after flooding it for two years, it was leased for three years, the lessee being allowed water free of charges for the crops grown on the reclaimed land. Of the 40 acres enclosed, 33 acres were reported in 1882 as being "fairly productive." Excluding the value of the canal water, there was a net profit of R586 at the conclusion of the experiment.

Exclusion of grazing.

At three other areas the effect of excluding grazing from usar land was tried. This was done at the Juhi reserve near Cawnpur, and at two enclosures, Gursikran and Cherat, near Aligarh; the land at Juhi was enclosed in 1882, whilst that at the other two places named in 1885. They were all simply enclosed from cattle, and grazing strictly prohibited. The grasses have been examined annually and, as Mr. Duthie's reports show, they have gradually extended over the surface, until now there is hardly a spot on which vegetation of some kind is not present and what were originally reh-covered pieces of land are now for the most part without any salt on the surface at all.

Cultivation.

(*j*) The results of an experiment made at Amrawau, near Cawnpur, to test the effect of deep cultivation and heavy manuring have been published separately (*vide Nos. 12 and 13 of The Agricultural Ledger, 1893*).

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MANURES AND MANURING.

(INDIAN MANURES.)

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INDIAN MANURES: THEIR COMPOSITION, CONSERVATION, AND APPLICATION.

A Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

The ordinary Indian cultivator cannot afford to purchase manures from other countries, and the consumption of such materials is limited to a small amount required by planters. It may be said, in considering the manure supply of the Empire, that it consists almost entirely of materials produced in India. On the other hand, it is not to be assumed that there is no trade in manures, and although this trade possibly may not bear any large proportion to the total amount utilised, still it is a quantity which has to be reckoned with. Very large amounts of city manure, and considerable amounts of oilseed refuse of a non-edible nature, are certainly regularly bought by the cultivator.

Object of the paper.

2. The object of this paper is to set out what information exists on the subject of the several manurial materials which are available in India and, at the same time, to show what further information might be obtained regarding these materials and the importance of that enquiry.

Indian manures.

3. The materials which are more or less available to the Indian cultivator may be included in the following list:—

1. Cattle Dung and Urine.
2. Cattle Bedding materials.
3. Night-soil and other city refuse.
4. Oilseed refuse.
5. Bones.
6. Saltpetre.

7. River, Canal and Tank silt.
8. Green manures.
9. Influence of Leguminous crops.
10. Sheep folding.

Methods of value of manures.

In discussing the value of a manurial material two items of information are of importance. The one is its value as a manure, the other the amount available. The first of these may be appraised by its market value, or it may be valued according to the increase of a crop or crops which is found to be due to it. The former method, namely, the market value, depends on the supply and demand for the time being, and will consequently vary considerably even in short periods of time as will become particularly evident when considering the oilseed refuse; the second method is one which is entirely independent of such fluctuations and may be said to be of an *absolute* nature for any particular area which enjoys substantially the same climate, and experiments are being conducted at different Experimental Farms for the purpose of determining this value for a number of materials. Climate *may* cause a manurial material to be more valuable in one part of the Empire than in another, in that a larger increase of crop may be obtained from a certain amount of manure in one part than in another. The information available is, however, too slight to admit of much being said on this point.

Experimental Stations in India.

4. In India there are at present the following Experimental Stations, at which, among other operations, the agricultural value of different manures is being determined: Poona, Nagpur, Cawnpur, Dumraon, and Burdwan. At each of these some experiments are now in progress which, it is anticipated, will eventually show what value may be placed on the several materials named in paragraph 2. But, although in several cases the experiments have now been in progress for some 10 or 12 years, the majority of the experiments have not been carried on for a sufficiently long period to allow of them being considered complete.

Amount of manure available.

5. A knowledge of the relative amounts of the several manurial materials available in India is naturally of importance; for from it may be deduced the relative importance of each. This information is, however, not easily obtained, and at the most only rough estimates can be arrived at.

I.—CATTLE DUNG AND URINE.

Value of cattle manure.

6. At all the Experimental Farms named in paragraph 4, cattle manure is being applied to various crops, and the experiments have now been in progress for some years. Until recently, however, the manure was badly cared for and no attempt to imitate European example was followed. It was held by some that cattle would suffer in various ways, such as from sore feet, if kept in sheds with bedding beneath them, and although others had shown this to be a fallacy, the fact remained that at the Cawnpur and the Bengal Farms no such thing as conserving cattle manure was attempted. What was collected for use on the farms was merely the solid excrement which

was kept in a hole. The urine was entirely lost. Thus the experiments at these farms may be said to have been carried out with the solid excrement only. At Nagpur much more care was bestowed and the manure obtained has been of good quality. In *The Agricultural Ledger* No. 9 of 1894 (Agricultural Series, No. 7), I have set out in detail what were the results of the experiments on the value of cattle manure which have been in progress at the four farms named above, and it would serve no useful purpose to reproduce the contents of that paper here. The additional information since gained verifies the results there detailed; the increase (since 1893) due to cattle manure has been somewhat above the average owing to the seasons having been generally favourable. The general conclusion which one may draw from these experiments is that, with an application of about 6 tons per acre of cattle manure, there will be obtained an increase of some 300 or 400℔ of wheat per acre in the North-Western Provinces or Bengal. At Nagpur the results are somewhat discordant owing to the serious attacks of rust which have been experienced, but generally there has been an increase of 200—300℔ of grain. In the case of maize an increase of 400—500℔ may be depended upon in any average good year, though the crop is more liable to suffer damage from bad weather than is the case with wheat, and in that case the gain will not be so great. The information in the case of rice is too uncertain to allow of safe deductions. It may be indeed that it is not true economy in most parts of India to apply cattle manure for rice at all. This point will be referred to again in a future paragraph.

Amount of cattle manure available to the ryot.

7. In paragraph 13 of *The Agricultural Ledger* referred to, I pointed out that the value of the results of these experiments very much depends on whether the amount of cattle dung employed, namely, about 6 tons per acre, is one which a cultivator may be said to have at hand.

A rough estimate of the amount of cattle manure may be obtained if we either weigh the quantity produced by cattle in a village or that produced at the farms. I have obtained information by both methods. When on tour in Ondh in December 1894, I collected and weighed the dung of several herds of grazing cattle. The herd was in each case kept for 24 hours within a moderate area. The weights are as follows:—

Instances.

(1) Herd of 50 cattle gave an average of 16·79℔ per head per day, or 6,132℔ per annum.
(2) Herd of 49 cattle gave an average of 13·68℔ per head per day, or 5,000℔ per annum.
(3) Herd of 25 cattle gave an average of 15·81℔ per head per day, or 5,767℔ per head per annum.
(4) Herd of 43 cattle gave 10·87℔ per head per day, or 3·967℔ per head per annum.

The mean of these four experiments is 5,216℔ per head per annum. The herds consisted of bullocks, cows, and calves, and they received a ration of straw in addition to the grass they grazed, which I was assured is the usual custom. These herds did not contain the working

cattle, they consisted of the idle ones, young stock and milch cows of the villages. Weighments at the farms give the following results.

At the Cawnpur Farm, the mean weight of dung from the work cattle over a period of 17 months was 4,048lb per head per annum, for the *night* period only; that of the day time being excluded, because it was assumed that it would in the case of a cultivator be either dropped on the road or in the field.

At Dumraon the mean weight obtained over a period of 2 years and 3 months was 5,258lb per head per annum; in this case likewise only the night's manure being weighed.

In both cases the manure was weighed after remaining in the pit, until the manure was required for the fields. The weight of the bedding and urine at Cawnpur was equal to 1,687lb per head per annum when taken from the pit.

8. Regarding the weight of manure from the grazing cattle it might be urged that it will count for nothing, because it is dropped on the grazing area, and that, consequently, it will not be collected. This is at least what I myself should have expected would be the case. In practice it is the reverse. When I collected the first herd in Oudh, I went over the ground carefully to see that all old manure should be removed and so not included in the manure of the day of the experiment, but, to my surprise, there was *none at all!* It had all been collected and carried away for fuel. If the people can find time to take it for one purpose, they can take it for another, and consequently, one may assume that, not only the manure of the work cattle, but also that of the grazing cattle, might be used for the crops.

The amounts of manure as above detailed show that each head of grazing cattle (which includes cows and young stock) will produce about $2\frac{1}{2}$ tons of manure, and that the work cattle will (during the night only) produce not less than 2 tons.

Amount of Cattle Dung per acre.

9. Now, since the question which we desire to form an opinion upon is, whether 6 tons of cattle manure is an amount which may be fairly supposed to be available for the land, it is necessary to consider over what area this manure might be applied if it were all preserved carefully. It will be allowed in the first place that one would not, in ordinary practice, manure every crop alike.

English practice.

In England a part of the agricultural economy practised consists in definite systems of "rotation." A very common rotation consists in growing roots, barley, grass and clover, wheat, in the order named, and the various other rotations adopted of a less definite character consists essentially in alternating roots and leguminous crops with cereals. In the case of the "Norfolk" rotation (roots, barley, grass, wheat) manure is always applied to the root crop and sometimes for the wheat, the barley is frequently manured indirectly because roots are often fed to cattle and sheep on the land; the grass or leguminous crops are grown with no additional manure.

Indian practice.

For India it may be said that the "Garden" crops generally or always receive manure, and that for sugar-cane and opium manure is nearly always applied, and it is also probable that this is a good rule to adopt. Certainly in the case of sugar-cane and potatoes it pays

well to manure heavily. But for the other crops, *e.g.*, wheat, maize and the millets generally which occupy much the greater area (excluding rice), we have little or no information as to any common practice. It is usual in many parts to grow a *rabi* crop one year, and a *kharif* crop the next, on the same land.

A very common practice, more especially in Behar and the North-Western Provinces, is to grow the vegetables (or "garden" crops) close to the village site, and it is this area which receives the main portion of the "house-refuse" manure. In other parts, however, such as in Gujerat, the people live a great deal away from the village during the dry season. They set up a thatched hut and remain there until the crops are reaped. Under such circumstances the "House" manure becomes distributed over a much larger area—a system infinitely better than the one so common in the North-Western Provinces.

10. Then, again, cattle manure is not the only manure generally available. Of night-soil and house-refuse there is probably as large an amount in any village or hamlet as of cattle manure, and there is frequently some tank mud in addition. Leaving out of account the latter, and assuming the "house manure" to be equal in amount to the cattle manure, we may say that the latter might form (if it were not required for fuel purposes) about one half of the manure supply of any village. Cattle Dung not the only manure.

11. We may assume, however, that it is not good economy to manure pulses. Our general knowledge of these crops indicates that they can do better without manure than can the cereals and millets. In the case of the rice crop also there is some evidence, which will be dealt with under the chapter on River and Canal Silt, indicating that this crop also can get along better without manure than the cereals. We have then left, the area under cereals, millets, sugar-cane and garden crops to consider. Considering that the "house" manure may be valued as equal to the "cattle" manure, we may, without using any unfair argument, assume one half of the above crops to be manured with house manure and one half remains which might be manured with cattle manure. Crops not requiring manure. Crops which require manure.

12. In 1893-94 the total nett area in the North-Western Provinces under all crops was 25,503,312 acres. From this we may deduct the areas under rice (5,033,689), gram (2,187,565), half of the area under "pulses, etc." (5,895,135), indigo (348,775), and orchards (219,783), leaving an area of about 12,000,000 acres which would be much benefited by manure. The number of work cattle in these Provinces is 7,250,000, each of which may be assumed to produce 2 tons of manure per annum (in the night only), there are also some 10,000,000 other idle cattle, each of which will produce about $2\frac{1}{2}$ tons of manure per annum; the total available supply being thus close on 40,000,000 of tons; and this, if we assume it to be used for half the crops requiring manure, is equal to more than 6 tons per acre. Thus, assuming the method of calculation adopted not to be open to any too great error, it must be admitted that the rate of manuring, which has been adopted at the farms, is not too high. Area. Number of Cattle. Weight of manure per acre.

Objections to the calculations. Manure required for fuel.

13. At the same time objections may easily be taken to the foregoing calculations. First and most important of all is the fact that, at present the manure is largely required as fuel, and so long as this practice is adhered to, the manure cannot be employed to raise crops. As to this question about which opinions differ so largely, only one thing can be asserted, and that is that there *are* parts of India where no cattle manure (or at least very little) is burnt at all (Gujerat, Muzaffargarh, Dera Dun are examples which have come under my observation); and, secondly, that in at least one part (Gujerat) the people grow their own fuel along the field borders, and it can certainly *not* be said that this is impossible elsewhere. More than this I shall not say. My object is to show what the cattle manure is worth. Then, again, it may be asked whether the evidence adduced above as to the weight of cattle dung is sufficient to form such an estimate upon? There is, however, additional evidence from other farms. At Burdwan the weight of dung produced by 6 bullocks (during the night) over a period of about 10 months was equal to 3,721 lb per head per annum. At Nagpur it amounted to 11,630 lb per head per annum. At Poona the dung collected from the dry milch cattle and young stock during 4 months was equivalent to 6,380 lb per head per annum. Thus, whilst the weight of manure obtained at Burdwan was somewhat less than at Cawnpur and Dumraon, at Nagpur it was far more, and it was also much more at Poona. Then, too, when on tour in Gujerat, Mr. Middleton, Professor of Agriculture, Baroda, helped me to estimate the amount of cattle manure used in one of the villages. It came to about 4,800 tons per annum. About 1,000 tons had to be brought from outside, leaving some 3,800 tons produced by the village cattle. The latter numbered 1,000 which gives an equivalent of 3·8 tons per head per annum. This evidence tends to show that the weight of manure obtained at Cawnpur and Dumraon was not anything unusual; it must be allowed to be a fair estimate. Finally, regarding the area taken, namely, one half that occupied by cereals, millets, oilseeds, sugar-cane, and garden produce, it is of course merely adopted to enable one to form some idea of what area there is which it might be desirable to manure. It must not be assumed that one would manure all crops uniformly. It will probably pay better to manure some much more liberally than others. On this point we have too little evidence to admit of going into much detail. On the other hand, it must be recollected that no account has been taken of the fact that the Cawnpur experiments have shown a distinct advantage to the wheat crop exerted by a previous leguminous one, the latter being removed. The results will be dealt with in detail in a later paragraph. There is some irregularity in the results, but generally a distinct, and in some cases a very considerable, increase in the wheat crop has been experienced. Such evidence is not novel. It is well recognised in Europe and the cause is now well understood. The area occupied by leguminous crops in India is very large, and since they thus probably exert a "Manurial" influence, that influence must be assumed to be exerted on a part at least of the area under cereals, etc., leaving probably a smaller area than the one

Evidence in support of weight of Cattle Dung.

Area adopted is probably a fair one.

adopted in paragraph 12 to rely on cattle manure. The experiments on the value of cattle manure at the farms must, on the whole, be allowed to be of a practical nature, and that the rate of manuring is one which may in ordinary practice be realised.

Composition of Cattle manure.

14. ***The Composition of Indian Cattle Manure.***—In paragraph 121 of his Report on "The Improvement of Indian Agriculture," Dr. Voelcker compares the chemical composition of Indian cattle manure with that made in England, a comparison which showed that the Indian manure was quite as good as the European. At the same time Dr. Voelcker points out the desirability of extending the investigation, the evidence which he had at hand being limited to two analyses. I can now add some evidence on this point, having analysed a number of samples of manure made at the farms and also some produced by cultivators' cattle.

Dung of Grazing Cattle.

Dung of Work Cattle.

The accompanying statements exhibit the analyses of a number of samples. Considering, in the first place, the composition of dung of the cultivators' cattle, which is set out in Statement No. I, it will be seen that the percentage of Nitrogen and Phosphoric acid is much lower than that in the manure from the farms—*vide* Statement No. II. This manure was, however, from cattle which had nothing but very poor grazing to which a ration of straw or juar stalks was added. Work cattle, though not highly fed, are frequently supplied with a little additional food, such as oilcake, more particularly when doing heavy work, and whilst these analyses probably represent the composition of dung from grazing cattle, those in Statement No. II will more nearly represent that of the work cattle.

Statement No. I.—Composition of Dung of Grazing Cattle.
1893-94.

	407.	408.	409.	410.	411.	418.	434.
	Banthra.	Banthra.	Banthra.	Banthra.	Chinhat.	Bara Banki.	Kaswarpur.
Moisture . . .	76·05	75·62	77·18	78·27	78·84	75·61	73·95
Organic matter . .	14·90	...	...	14·46	13·43	14·69	15·95
Siliceous „ . .	7·24	7·88	7·98	6·92	6·67	8·46	8·24
P_2O_5	·182	·188	·173	·173	·167	·192	·126
N	·273	·217	·290	·207	·237	·269	·251

Statement No. II.—Composition of Cattle Manure at Experimental Farms.

	Sibpur.	Cawnpur.			Nagpur.	Dumraon.			Burdwan.		
	1895.	Dung.	Litter and Urine.	Farmyard Manure.	Cattle Manure.	Cattle Dung.	Cattle Dung.	Cattle Dung.	Cattle Dung.	Cattle Dung.	Cattle Dung.
Moisture	65·48	46·60	25·38	33·86	62·77	32·85	71·59	25·96	59·19	72·23	67·84
Organic matter	17·16	21·30	12·69	17·11	15·32	24·22	...	...	...	...	...
Siliceous "	12·27	24·56	52·39	40·98	16·80	31·28	12·85	41·45	22·30	11·38	12·85
P_2O_5	·597	·566	·290	·498	·755	·387	·299	...	...	...	...
N	·606	·811	·460	·652	·597	·656	·483	·847	·613	·464	·465

Generally, it may be said that the manure made at the farms is fully as good as that made in Europe. It is, however, frequently much drier.

15. ***The "Conservation" of Indian Cattle Manure.***—Of late years much more attention has been paid in England to the conservation of Farm manure. The researches of the late Dr. Voelcker showed that the valuable constituents of cattle manure, namely, the ammonia and other nitrogenous matters, the potash, the phosphoric acid, were largely in a soluble condition, and that if the manure were exposed to the weather, the rain would doubtless wash away more or less of these constituents, and they would thereby become lost to the land. On the other hand, it was shown that the loss by evaporation of the ammonia (or ammonium carbonate which is a volatile substance) was, under ordinary circumstances, probably but very slight. As an outcome of this, farmyard manure has been much more carefully kept; it is preserved in good square heaps and the drainage water is thrown back upon it from time to time; or what is a still greater improvement consists in the introduction of the "box" system. In India it may be said, without fear of contradiction, that one *rarely* sees any care at all bestowed by the cultivator on his farm manure heap. I do not refer here to that manure which is burnt, but to that which is in villages generally retained for application to the land. A common practice is to dedicate a hollow near the dwellings to the accumulated rubbish of the houses; another is to throw these materials on the banks of the village tank. In only two places have I found much attention given to the manure heap, the one is Gujerat, the other Dera Dun. In Gujerat especially is the general practice good. Many planters also pay great attention to the conservation of the cattle manure, and there may be other instances. The general rule is, however, as above stated. Dr. Voelcker in paragraph 148 of his Report cites examples of what he met with, and I may add a few of those which have come under my own observation. Around Banthra and Chinhat (Lucknow District) the manure heap is usually placed on the sides of the village tank, and in this case, it may be said, to be nearly all lost. Sometimes, as in a village near Lucknow, the heap finds a place on the side of the road. In other places, such as Satrikh (Bara Banki) a hole in the ground receives all refuse. This is indeed by far the most common practice; the hole is not a square, well made one, but a mere hollow, and the refuse is thrown into it.

Reason for conserving Cattle Dung.

Improved methods in England.

Neglect in India.

Examples.

This practice I have also observed in Bengal and in the Panjab. Generally in such a case the material is perfectly dry and the straw and twigs are not rotted at all. On the other hand, in Gujerat the manure is usually plastered down on the heap, which is gradually built up in a square well-kept hole, and one finds moisture close to the surface, and the dung well rotted; in the Dun the manure is carefully put in a hole and kept solidified, so that when brought on to the land it is quite rotten.

16. At some of the Experimental Farms the system adopted at present is to put the dung and litter into a hole over which a thatch is placed. It has been generally assumed that the important point is

Methods at the Farms.

Difficulty in keeping the Manure damp.

to keep off the rain during the monsoon. But so far the general experience has been that considerable difficulty exists in rotting the bedding material properly. The manure dries so dreadfully fast that there has frequently been far too little moisture in the heap and, instead of fermentation, molds form, accompanied by very great heat. It is common for a manure heap to be so hot about a foot below the surface that one cannot take hold of the material. At Nagpur it has been found desirable to throw some water on the heap in the hot weather, grass is also placed over the top and a thatch in addition, to keep off the *sun*, not the rain! With the pure cattle manure there is not much difficulty, but when bedding is also present, the heap is if anything too dry. It is probable that we have much to learn yet as to the best way of storing farm manure in India. The "box" system has been tried at Nagpur for some years, the amount of manure gradually rising to four feet in depth, and the same system is being tried also at Cawnpur. No evil results to the cattle have ensued so far, and if no other difficulties are met with, it will probably mean a considerable gain in the manure supply on the farms.

The "box" system in India.

At only two places in India have I found the cultivators' cattle kept standing on the manure. In the Bahraich District, around village Jarwal, and in the neighbourhood of Kinhauli, Bara Banki District, the cattle are kept under sheds with some bedding material, and 6 or 8 inches of manure gradually collects. The other instances is the method which is in vogue in some parts of Gujerat. The cattle are herded at night in a pen, which is set apart for the purpose, and the manure is allowed to collect on the ground until required. At the time I visited Gujerat in 1895 (March), the manure was naturally all dry and formed a layer about 4 to 6 inches thick.

II.—CATTLE BEDDING MATERIALS.

Bedding sometimes employed.

17. That it is an advantage to employ bedding under cattle in Europe needs no assertion here. The advantages of the system are well recognised and the practice is general. In India, on the contrary, cattle are generally tethered without any bedding at all, the exceptions to the rule which have come under my observation being the parts of Bara Banki and Bahraich to which I have referred in the previous paragraph, and the practice of tea and coffee planters. Dr. Voelcker in dealing with the question of bedding cattle so as to collect the urine (paragraphs 146 to 149 of his Report), refers to the argument used by cultivators that they have no straw for bedding, and proceeds to mention various refuse materials which are generally found in villages.

English practice.

18. In England much more is spent on both food and bedding for cattle than in India, and doubtless the English farmer can afford to spend more than his Indian compeer. The value of farm animals generally is much greater in England, and the supply of straw, etc., *available* for bedding is also larger. It must not be supposed, however, that the English farmer has unlimited supplies of straw. On the

contrary, both peat and saw dust are being used for stables and cattle byres which shows that the home farmer has to pay a price for his bedding material.

Straw of Indian crops mostly required for other purposes.

19. Judging by enquiries I have made when on tour, it would seem that the refuse of various crops, that is, the parts which are not used for human consumption or in the arts is mostly put to certain uses and is really required. The straws are largely fed to cattle and form indeed the main part of their food supply. Rice straw is employed largely in thatching. The small stems, leaves and husks of the pulses are also fed to cattle; thick stems, *e.g.*, those of *arhar* and the castor-oil plant are used in thatching; those of indigo are largely put on the land for manure (which is their proper destination) though sometimes it is used as fuel; the "megass" of sugar-cane is required for fuel, the green leaves of sugar-cane are fed to cattle, the *dry leaves* are largely burnt on the field. The dry leaves of trees are used largely for grain parching. Thus taken as a whole, it would seem that the major portion of the stems and leaves of the crops are put to other uses, and one cannot say that the practice is bad in general.

Sugar-cane leaves available.

20. Indeed the only point in the system which appears to me to be faulty is the burning of the dry leaves of sugar-cane, which is done in the field after the crop has been removed and is certainly wasteful. So far as this material is concerned, I may say that it forms an excellent bedding material, it is the only one employed at the Cawnpur Farm. Nor can it be said that this is a very small item. In the North-Western Provinces there are 1,000,000 acres of sugar-cane, the weight of dry leaves will not be less than 700℔ per acre which would be a very liberal supply for two beasts for a year; thus the sugar-cane of the Province would, taken as a whole, supply bedding for 2,000,000 or about one-third of the work cattle. Of course sugar-cane is not uniformly cultivated even in the one province—in some parts it is less cultivated than in others, so that it would not be true to say that one out of every three of the work cattle of every village might be bedded with the dry sugar-cane leaves of the village; but sugar-cane is so very generally cultivated in villages throughout India, that it must be allowed this material does by itself really form a very large and general supply. But apart from this and allowing that there is a scarcity of bedding material, the Scotch proverb, "Many a mickle makes a muckle" might be appropriately quoted as indicating how more bedding might be found. Any one who has watched cattle feeding on such things as juar stalks and even straw in the villages, must have observed that there is always some wastage. There are also the leaves and other dry vegetable debris of every village, and certainly some of this would serve the purpose under consideration. It is in this manner that the bedding supply of the country might be augmented. If the people practised economy in this respect as they do in many other directions, a very great increase in the manure supply would be the immediate result. I have come to the same conclusion as Dr. Voelcker in this matter, namely, that the

people do *not* in many parts know how to preserve cattle manure properly; it is a matter which can only be explained to them gradually, and, as agricultural education spreads, we may anticipate an improvement in the practice of this chapter of agricultural economics.

Loose earth as a substitute.

21. There is possibly another means of securing cattle urine, instead of employing bedding, and that is by spreading loose earth in the stalls. Dr. Voelcker in paragraph 146 of his Report mentions this, and it is certainly a means which deserves trial. An experiment is now being conducted at the Cawnpur Farm with it, but the experience gained is too short to admit of an opinion being formed. The principle is perfectly sound. It is based on the fact well known that earth forms an excellent absorbent of various soluble matters. It will absorb, *i.e.*, take up such things as potash and ammonia salts, and organic matters from their solution in water, and the drainage water passing away will be found to be poorer in them than before. Moreover, in actual practice the amount of earth required to wholly absorb urine and thus to allow no drainage whatever is not great, and if it be dried, as it may readily be, throughout the greater part of the year, in a few hours, the same earth may be again employed and again dried. How long the process might be repeated on the same quantity of earth is a question which experiments alone can decide. Other questions may doubtless occur in practice, but it is probably a practical way of securing the greater part of the urine deposited in the villages.

22. One set of analyses which I made to test a point in relation to this subject may here be detailed.

In paragraph 16 I have explained that in Gujerat the village cattle are penned in an enclosure, and that the manure is allowed to collect. I took three samples of the earth below the manure, the first being the top soil 1″—6″, the second, the next soil underneath, 6″—1′ 6″, and the third from the depth 1′ 6″—2′ 6″. The proportion of Nitrogen was determined in each in order to see how far the soluble Nitrogen compounds had descended; a sample of the surface soil from the neighbouring (rice) land was analysed to indicate the amount of Nitrogen in the soil generally. The soil was of the type known as "black cotton," and as this is one of the most "open" soils known, one would expect the salts to pass lower down than in such a soil as that of the alluvial areas. Statement No. III contains the figures.

Statement No. III.

1″—6″	6″—1′ 6″	1′ 6″—2′ 6″	Rice land. 1′—6″
% Nitrogen.	% Nitrogen.	% Nitrogen.	% Nitrogen.
·152	·045	·034	·068

M. 237-59.

It will be seen that the amount of Nitrogen in the soil at 6″ deep (·045) is rather less than in the rice land soil, and since the proportion of Nitrogen in the soil at 1′ 6″ is very little different from that at 6″, it may be assumed that none of the ammonia salts had passed lower, if as low down as 6″; *i.e.*, the first few inches of soil had retained the valuable salts of the urine entirely. The analysis of one sample of cattle urine from the Cawnpur Farm may here be quoted.

Water.	Organic matter.	Mineral matter.	Nitrogen.
91·84	2·57	5·59	·87

III.—NIGHT-SOIL AND TOWN REFUSE.

23. That the night-soil and other refuse of town and villages is of great value as a manurial agent requires no assertion here. It is a fact well known to all. Further, that a great part of the materials thus included go directly on to the land is also well known. The customs of the people inhabiting "hamlets" and the outskirts of towns and large villages secure material economy in this matter. On the other hand, there is a large part which is not brought directly on the land, but has to be carried from the houses. In large towns various systems are in vogue for dealing with this; in villages the need of a system is patent to all who pass through their bye-paths.

Some goes directly on the land.

Some requires removing.

24. Regarding the proper disposal of these matters in the case of large towns, there are several methods in use and three of them have been dealt with in *The Agricultural Ledger No. 16 of 1895* (Agricultural Series, No. 15) and do not require more than a mention here. They are the "poudrette," the "deep trench" and the "shallow trench" systems and are employed for the disposal of human fœces.

Modes of dealing with night-soil.

25. The composition of poudrette will vary very considerably according to whether it be dry or damp, or whether much or little ashes are employed in its manufacture. The poudrette employed for the Poona sugar-cane experiments has usually contained from 15 to 25 per cent. of moisture, and from ·9 to 1·1 per cent. of Nitrogen. The Cawnpur poudrette has generally contained more earth and less moisture (only about 3 to 6 per cent. of water); the proportion of Nitrogen has varied from ·4 to ·7 per cent. The proportion of Phosphoric acid varies very much more and depends probably on whether ashes are largely employed in its preparation; one sample from Poona contained only ·2 per cent., whilst another contained 1·5 per cent.

Composition of poudrette.

26. Regarding its value as a manure the following experiments may be quoted. At Cawnpur it has been applied for 14 years to maize (two plots) and to wheat (two plots). The following Statements Nos. IV and V contain the results—expressed in pounds per acre.

Value of poudrette.

Statement No. IV.—Showing the mean outturn of Maize per acre at Cawnpur.

Maize.	Mean of three years, 1884-87.	* Mean of three years, 1889-92.	Mean of three years, 1892-95.
	lb grain.	lb grain.	lb grain.
"Standard" Series—180 mds. Poudrette (6·6 tons)	974	1,319	1,146
"Duplicate" Series—180 mds. Poudrette (6·6 tons)	1,249	1,472	1,535
"Standard" Series—180 mds. Cow Dung (6·6 tons)	1,031	1,145	1,014
"Duplicate" Series—180 mds. Cow Dung (6·6 tons)	950	963	800
"Standard" Series—No Manure . .	606	564	686
"Duplicate" Series—No Manure . .	321	581	470

Statement No. V.—Showing the mean outturn of Wheat per acre at Cawnpur.

Wheat.	Mean of four years, 1884-88.	Mean of four years, 1888-92.	Mean of three years, 1892-95.
	lb grain.	lb grain.	lb grain.
"Standard" Series—180 mds. Poudrette (6·6 tons)	1,208	1,512	1,701
"Duplicate" Series—180 mds. Poudrette (6·6 tons)	1,641	1,709	1,850
"Standard" Series—180 mds. Cow Dung (6·6 tons)	1,237	1,358	1,742
"Duplicate" Series—180 mds. Cow Dung (6·6 tons)	1,495	1,800	1,417
"Standard" Series—No Manure . .	889	1,101	1,033
"Duplicate" Series—No Manure . .	1,077	1,261	1,140

* *Note.*—The maize crops were an entire failure in the years 1888 and 1889.

M. 237-59.

In several years the maize crop has failed on account of excessive rain. The Statement No. IV exhibits the means of three periods of three years each. The outturn obtained with Cattle Dung is also inserted for comparison. In the two "Standard" Series maize and wheat respectively is grown every year, whilst in the "Duplicate" Series maize and wheat alternate with one another. There are two "Duplicate" Series of plots on which wheat and maize are grown in alternate years, so that a maize crop is obtained from either the one or the other "Duplicate" Series of plots each year. Although the results are not quite uniform, it is clear that a larger outturn of maize has been obtained from 180 maunds of poudrette than from a like weight of Cattle Dung.

In the case of wheat, the outturns of which crop are detailed in Statement No. V, the 180 maunds of poudrette has not produced much more wheat than the same weight of Cattle Dung.

At Poona, in the case of the sugar-cane grown in 1894-95 and 1895-96, there has been obtained in both years a *much* larger amount of sugar from the plot manured with poudrette than from the one to which an equivalent amount of cattle manure was applied. Thus, these experiments indicate not only the increase of produce due to poudrette, but show that the poudrette has, in the case of maize and sugar-cane, produced more than a similar weight of cattle manure.

27. One important point must also be referred to. It may be advisedly asked whether the *same weight* of poudrette and cattle manure really means approximately an application of like amounts of plant foods, *e.g.*, Nitrogen, Phosphoric acid, etc. It is only during the last year or so that any analyses of the manures employed at the farms have been made, and consequently we know nothing of the composition of the poudrette and cattle manure which was applied at Cawnpur during the years to which the statements refer. But if they have been generally of the same quality as that employed recently, both these manures will have contained much about the same amounts of Nitrogen. The amount of Phosphoric acid has probably varied a good deal, but since the experiments generally at all the farms indicate that Nitrogen is the principal controlling factor for (at least) cereals, millets and sugar-cane, it may be assumed that the manures have really been applied in equivalent quantities. At Poona the manures were analysed each year and approximately equal quantities of Nitrogen applied.

Amount of Night-soil available.

Some information relative to the amount of night-soil available which I have received from Meerut and Nagpur will be of interest. A part of the night-soil and sweepings of Nagpur is brought to the farm, and there converted into poudrette for the colony of Kachis which were imported in 1882 by Mr. Fuller from the North-Western Provinces. About 400 cubic feet of night-soil and 140 cubic feet of sweepings are obtained *daily* from a part of Nagpur, the population of which is 24,000. The above quantity is sufficient to fill one pit and forms about 218 cubic feet of poudrette (a considerable quantity of liquid apparently drains through the bottom). When this poudrette is considered fit to put upon the land, it weighs about 6,260lb; the loss due to drainage and drying being apparently equal to more than 70 per cent. The poudrette manures 23·75 acres, and

the average amount of poudrette applied per acre is thus equal to $(6{,}261 \times 365 \div 23{\cdot}75) = 96{,}220$lb or some 43 tons. This, it may be mentioned, is similar to the amount of poudrette which the cultivators around Poona employ for sugar-cane. At Meerut the Municipality removes about 210 maunds of night-soil daily from the city, the population of which is about 73,000. This is *trenched* and not made into poudrette, and manures 16 *kucha* bighas, or only about 3 acres annually. If it were converted into poudrette, and assuming that 75 per cent. is lost as at Nagpur, it would form some 4,000lb of poudrette daily, or more than 600 tons annually. It is, however, applied direct to the land and the losses due to drainage cannot approach those obtaining at Nagpur; the manure must be assumed to be equivalent to much more than 600 tons annually, and thus *the rate is probably equal to more than 200 tons per acre!*

The sweepings of the Meerut streets are partly used for brick-burning and partly put into pits, which are sold later. Each pit receives the contents of 60 carts; 1 cart contains 30 maunds; this quantity (1,800 maunds) is commonly applied to 4 bighas *kucha* or, say, $\frac{4}{5}$ acre, which is equivalent to about 80 tons per acre. Sweepings are not generally nearly so concentrated a manure as poudrette; assuming them to be half as valuable, this rate becomes about equivalent to that which the Nagpur Kachis apply. At Allahabad, where the shallow trench is employed, 70 gallons of night-soil is applied to 9 square yards which is equal to $[(700 \times 4{,}840) \div (9 \times 2{,}240)]$ about 168 tons per acre; but the land is only manured once in 10 years. 130 to 140 carts (70 gallons each) of night-soil and 70 carts (1 ton each) of sweepings are here applied daily, and manure about 200 acres of grass land annually, and since one manuring is assumed to be sufficient for 10 years, the total area manured is assumed to be 2,000 acres. Although this land only produced grass, the produce per acre is very high. For instance, the following outturns are published in Statement C (page 14) of the Report for 1892-93:—782 maunds per acre, land manured 5 years previously; 257 maunds from lands manured 7 and 11 years previously; 850 maunds from land manured 5 years previously; 277 maunds from land manured during preceding 4 years; 378 maunds from manured land. Thus from 10 to 30 tons of green grass (equal to 3 to 10 tons of hay) is removed per acre, and is equal in its requirements on the soil, to the heaviest agricultural crops grown. The foregoing illustrate the comparative areas on which night-soil and sweepings are applied. The Allahabad rate, though high in the first instance, is much the lowest in reality, being, in the case of the night-soil, about 17 tons per acre per annum. The rate of about 43 tons of poudrette per acre per annum at Nagpur and that of 80 tons of sweepings at Meerut are certainly high; but when the weight of night-soil applied per acre at Meerut is considered, it must be admitted as being altogether far too high for any land. It is not improbable that the same manure might be put on five times the area and still yield as good crops.

Sweepings.

28. From towns there is also that refuse which may be designated "Sweepings," and which includes all the various materials which are swept from the streets. Considered in comparison with many other

manures, this material, although it will vary considerably, is not a very rich manure. A sample from Poona contained ·4 per cent. Nitrogen and one from Dumraon ·3 per cent. Nitrogen. Its quantity, however, is very large, and, provided it can be utilised near a town, it becomes a very valuable item. If its proportion of Nitrogen be low, it, on the other hand, contains in addition a considerable amount of organic debris and ashes, materials which assist in opening up the soil. As examples of how it is disposed of the following may be quoted.

At Allahabad it is bought for the grass land of the Commissariat Farm where it is applied in two ways: (1) it is simply spread on the grass land; (2) it is put into trenches, 1 foot deep and 6 feet broad; the latter is naturally far more expensive than the former, but a much greater quantity is applied per acre and the effect will be correspondingly more lasting; where the land has become very hard through long periods of grazing this method will probably pay.

At Meerut the material is stored in pits and later sold to cultivators. At Nagpur it is utilised in the poudrette pits. On the other hand, very large amounts of sweepings are annually consumed in brick-kilns; at Meerut, Cawnpur, Dumraon, Nagpur it is thus used. **Some part used in brick kilns.**

29. In addition to the night-soil and "sweepings" there is another refuse material obtainable from towns, namely, the "Sullage" or Drainage Water. This is, I believe, not generally brought upon the land, but is allowed to run into the nearest river. Its value will doubtless vary according to the amount of water passing down the drains, but at Meerut, where it has recently been used on the demonstration farm, two irrigations with it caused about one hundred per cent. increase in the case of cotton, maize, juar and oats, the four crops experimented with. The outcome of these experiments was that cultivators commenced forthwith to set up "Dhenklis" for raising the water on to the fields. There is probably room for a very large extension of the practice. **Sullage Water.**

30. Another source of town manure which, though limited, is fully worth mention, is a portion of that produced in jails. Generally it may be said that nowhere is more economy shown in the utilisation of manure than in the case of jails. The night-soil and urine as well as whatever cattle manure is produced, is brought on to the jail garden and very heavy crops of vegetables grown. **Jail Urine.**

This first case which I had an opportunity of examining was the Presidency Jail Garden, Calcutta, and I obtained through Mr. Donaldson, the Superintendent, some figures relative to the amounts of manure there used. Besides some 2,400 maunds of food stuffs grown in the garden, there was imported 2,700 maunds of pulses and 840 maunds of straw, and the whole of the manure was regularly trenched in the garden. This meant practically a very large importation of "manure" indeed; not less than 10 times as much of both Nitrogen and Phosphoric acid as there was in the vegetables grown. Of course for gardens it always pays to manure heavily, but it is probable that in such a case as the one quoted the manure might have been employed more advantageously on a much larger area.

Meerut experiments.

At Meerut recently Mr. Wyer, the Collector, has been experimenting with the utilisation of jail urine. It has been found that the jail garden can do without the urine, and it is simply thrown into pits which are afterwards filled up. It is, in the undiluted state, liable to "burn up" crops, and for this reason as well as the difficulty experienced in carrying it, it is not taken by the cultivators. Mr. Wyer has, therefore, commenced to try the experiment of absorbing it with dry earth. It has been found that a maund of earth will absorb (*if added gradually*) two maunds of urine, and since this becomes a dry material which can be carried in an ordinary cart, it should prove a very practical way of disposing of it. It would seem probable that there is a certain proportion of the manure produced in jails which would become available to the cultivator.

Some part lost.

31. ***Village Night-soil.***—Although in villages much of the night-soil goes directly on to the land, there is frequently no small quantity which does not. For example, one generally sees a dark coloured, most objectionable liquid oozing through a small hole from the houses into the road or into a small excavation at the base of the wall. This may be sometimes periodically removed to the fields, but in other cases it certainly accumulates, or rather runs away and never reaches the land at all. It is not the object of this paper to touch upon village sanitation, but I may mention a case which came under my observation and which seemed to be distinct improvement on the general run of things.

At Kaisarganj in the Bahraich District there is a fairly well-kept hole behind each house into which not only sullage water, but also all sweepings, etc., are stored. In such a case the dry materials absorb the sullage water, and the whole may be readily brought upon the land.

32. Although it is thus apparent that a great deal of useful manure is being regularly brought upon the land from towns, there is still, I am convinced room for considerable development of improved practice and corresponding gain both to the towns from the sanitary point of view, as also to the cultivator. Apart from the cost of collection, etc., a difficulty doubtless also lies in the cost of carriage. The manure might, I feel sure, be economically employed over a larger area if, instead of the poudrette system, something like the Allahabad "shallow" trench could be adopted. A hopeful sign is the fact that both at Poona and at Cawnpur the price of poudrette has been rising very considerably of late. At Poona the best poudrette sells at R4 per cart load and at Cawnpur the price has risen from annas 4 to R1 per load. It is perhaps rash to speculate too far, but if it pays to carry fire-wood at Changa Manga on a "light" tramway, it is quite possible that it would pay Municipalities to transport night-soil by the same means. There is generally little or no "push" exhibited by Municipal bodies in relation to the disposal of city refuse. If it were looked at more as a source of income than one of nuisance, much more might frequently be made out of it. At Meerut, for example, it has become in a few years from a debit charge of some R10,000 to an actual source of profit. An establishment, such as the little demonstration

Rise in price of poudrette.

Night-soils might become a source of *profit* to Municipalities.

farm at Meerut, may readily become (as in the instances quoted) a means of exhibiting the value of these manures to the people, and thus also an indirect road to enhancing Municipal revenues.

IV.—OILSEED CAKES.

33. In paragraph 127 of Dr. Voelcker's Report, attention is directed to the question of the export of oilseed and oilseed refuse. As is well known the oil of a seed has no manurial value, the oilseed refuse, on the other hand, has a very considerable one, and Dr. Voelcker urges that it is not good agricultural economy to send this material away—that rather the oil should be expressed from the seed in India and it alone exported. The "oil-cake" obtained should then be either fed to cattle or be applied to the land direct as a manure. That oilseed cakes have, with one or two exceptions, both a high feeding and a high manurial value there is no doubt. It is a fact well recognised in Europe generally and large imports of these materials are made from both America and India. Before going into particulars we may say that the exports from India are steadily increasing in all respects, *viz.*, in oil, in oilseeds and in oil-cake, but more especially in the case of the two last named. The important question is naturally, "What is this export really equivalent to so far as India in concerned?" Admittedly in a country where manure of all kinds is scarce, compared with the supply in some of the leading European countries, any deliberate export of materials useful as manure, is a mistake from the economic point of view. The trade, however, exists; a price is offered to the Indian cultivator for these materials and he accepts it. But since they are bought by agriculturists of other countries for precisely the same uses as those to which the Indian cultivator *might* put them, it seems clear that an economic blunder is being committed. It is truc that they are not only imported into Europe as manures, but, also, and this primarily, as cattle foods. In India they *should* be also employed in the same manner, for both the work cattle and land in India are even more hungry than are the fattening stock and the land of Europe. It becomes indeed a question as to who will pay the higher price for them—the European or the Indian agriculturist. It is quite clear from the fact that the export trade in oilseeds and oil-cakes is on the increase, that *at present* the European values these materials at a higher rate than the native of India; their price will only be increased in India as the people become more aware of their feeding and manurial value.

Increased exports.

Oil-cake as valuable to the Indian ryot as to the European farmer.

It is a case where demonstration can play a useful part, and as Dr. Voelcker has pointed out in the paragraph referred to, this should be taken up by Agricultural Departments.

Demonstration may do good.

34. Since the object of this paper is to show what the value of various oilseed cakes is as *manures*, their value as foods will not be discussed; the fact that they form in many cases very valuable fodders must nevertheless be kept in mind. The principal oilseeds of India are Linseed, Rape and Mustard, Sesamum, Cotton, Earthnut, Safflower, Cocoanut, Castor, *Mahuá* (Bassia latifolia), Pongamia

Principal oilseeds.

glabra and Poppy; the first seven are edible, the last four are not so.

35. ***Linseed.***—There are over four million acres of linseed grown annually in India to which must be added $3\frac{3}{4}$ million acres on which it forms a part of a mixture of crops. The pure crop is grown principally in the Central Provinces, Berar, North-Western Provinces and Bengal; the mixed crop is grown principally in the North-Western Provinces. The total average outturn is estimated to be about 647,000 tons. The seed is largely exported *as such*. In 1888-89 420,000 tons were exported, in 1894-95 the corresponding figure was 450,000 tons. In addition to this, 95,000 gallons of linseed oil were exported which is equivalent to about 1,200 tons of seed. From this it appears that nearly $\frac{3}{4}$ of the seed produced is exported as such, leaving about $\frac{1}{4}$ for consumption in India. No details of the exports of linseed cake are available. Linseed cake has not, so far as the writer is aware, been employed direct to the land as a manure in India. Its value as a food is so great that its price in Europe prohibits it being used as manure. It contains from 4 to $5\frac{1}{2}$ per cent. of Nitrogen.

36. ***Rape and Mustard Seed.***—About 14,700,000 acres bear different varieties of rape and mustard seed, of which some 9,700,000 acres bear other crops at the same time, rape or mustard forming one item of the mixture. The estimated average outturn is 1,221,000 tons of seed. Of this, 237,000 tons of seed were exported in 1894-95. In 1888-89 the corresponding figure was 150,000 tons, thus showing a considerably increased export. In addition 175,000 gallons of oil were exported in 1894-95 which is equivalent to about 2,100 tons of seed. Thus much the greater part of the seed produced is consumed in India; it is pressed and the oil-cake is regularly fed to cattle. Regarding the manurial value of the cake, no experiments have been made in India, but it has been employed for this purpose for many years at Rathamsted in England, and there 1,000lb of rape cake have produced a rather larger outturn of barley than 14 tons of farmyard manure. It usually contains, when pure, about 5 per cent. of Nitrogen, but there is frequently less than this on account of an admixture of sand and earthy matter.

37. **Sesamum indicum,** ***Til or Gingelly.***—The average area under this crop amounts to 1,900,000 acres, the greater part of this area lying within the southern half of the Empire. The average outturn is estimated at 176,000 tons. Of this the export as seed was 116,000 tons in 1894-95. The corresponding figure in 1888-89 was 77,000 tons, the export of this seed having increased very considerably. In addition 325,000 gallons of the oil, equivalent to about 4,000 tons seed, was exported in 1894-95. Thus it is seen that about $\frac{2}{3}$ of the total seed is exported as such, leaving $\frac{1}{3}$ for consumption in India. The cake forms a valuable cattle food and is fed to cattle in India. Regarding the manurial value of the cake no information is available. One sample analysed, contained 5·4 per cent. of Nitrogen.

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38. ***Cotton Seed.***—The average area under cotton in India is about 14,500,000 acres, and the average outturn of cotton is estimated to be 2,777,000 bales of 400lb each. From the weights of seed and lint obtained at Nagpur and Cawnpur, the weight of the seeds may be assumed to be twice that of the lint, and the weight of seed produced in India may thus be calculated to be about 992,000 tons. The export is very trivial; in 1894-95 it was 4,800 tons. Thus it is certain that nearly the whole remains in India. It is a valuable cattle food, and doubtless it is mainly consumed in this manner, though it is also probable that a very large amount is consumed by the milch cows and buffaloes in the towns. Regarding the value of cotton-seed cake as a manure, it has been employed for the sugar-cane crop at Poona last year, when it proved itself equal to certain other oilseed cakes and to poudrette applied (as they were) in proportion to their content of Nitrogen. It contains from 3-4 per cent. of Nitrogen.

39. ***Earthnut.***—There is no definite information as to the area under earthnut. The crop is largely cultivated in Bombay (159,226 acres in 1894-95), Madras (226,147 acres in 1894-95) and in Mysore. The crop experiments, which have been made in the Bombay Presidency, show that it is a heavy yielder, and although the information is limited to some half a dozen weighments, 1 ton of seed per acre will not be an extravagant figure to adopt. The area above quoted (385,373 acres in Bombay and Madras) would thus account for some 385,000 tons, but the total outturn must be much larger. The export of 1894-95 was 113,000 tons of seed; that of oil 18,000 gallons equivalent to about 200 tons of seed. The total outturn is not unlikely fully 500,000 tons, and the export would thus come to about $\frac{1}{4}$ of the whole production. The seed is largely consumed as human food. It also forms an excellent cattle food and is crushed both by itself or with safflower seed. Regarding its manurial value we have indirect evidence obtained from the use of "safflower and earthnut" cake in the Poona sugar-cane experiments in 1895-96, when it proved to be a very good manure. One sample of earthnut cake contained 7·4 per cent. of Nitrogen.

40. ***Safflower Seed*** **(Carthamus tinctorius).**—Regarding the safflower crop and the total outturn obtained there is very little information. In Bombay 571,804 acres were under the crop in 1894-95, but no returns are available for other provinces. Nor is there any estimate of its export. The seed is crushed for its oil in Bombay and Madras Presidencies, and the oil-cake is a most valuable cattle food. The cake was employed as a manure for sugar-cane at Poona in 1895-96 where it produced a very heavy crop. It contains 6-7 per cent. of Nitrogen.

41. ***Cocoanut Cake.***—Although this does not belong to the class "Oilseeds" in the general acceptation of the term, mention of it must not be excluded here, since the cocoanut is a fruit which produces both an oil and a very valuable oil-cake which is largely fed to cattle both in India and in Europe. No information is

available as to the supply of this material, nor is its value as a manure known. It contains about 3 per cent. of Nitrogen.

42. ***Castor-seed Cake.***—The area under castor-seed cake is only known for Madras and Bombay Presidencies; 728,047 acres and 114,940 acres, respectively, were under the crop in these two Presidencies in 1894-95. In Bombay the outturn has been found to vary from 180 to over 400℔ of seed per acre; the average outturn in Madras is stated to be 473℔ per acre (Watt's Dictionary). Since the plant is cultivated extensively all over India, the total area under the crop can hardly be less than 1,500,000 acres, and if 300℔ per acre be considered an average outturn, the tctal would amount to some 200,000 tons, and this is probably a low estimate. Of this 58,000 tons was exported as seed in 1894-95; in addition 2,679,000 gallons of castor oil, equivalent to some 34,000 tons of seed, was exported. The oil-cake is not edible, but it forms an excellent manure, and this is well known to cultivators in all parts of India. For instance at Poona and in Gujerat it is applied to sugar-cane, at Burdwan it is employed for potatoes. The price too has risen very considerably of late years; for instance, at Cawnpur it could be bought for R0-14-0 per maund 10 years ago, its price now being R1-8 and at Poona its price is R2 per maund now. In some parts there is a prejudice against it; for example, in the Lucknow District I found that the people would not use it for the pan vine (Piper Betle) although they applied the rape-seed cake; they objected to the castor cake as being "unclean." This is, however, merely an example of ignorant prejudice in a very backward part; the castor cake is increasing in value all over India. In fact it is actually cheaper at present to buy some of the edible cakes for manure than to buy castor cake. It is indeed partly for this reason that at Poona three different edible cakes are being applied as manures for sugar-cane. But the quality of castor cake varies to a much greater extent than is the case with most oil-cakes. Seeds, as a rule, are very uniform in composition, and when oilseeds are crushed, it is found that the proportion of Nitrogen which they contain does not vary very greatly. In the case of seven samples of castor cake obtained from Poona, the per cent. of Nitrogen varied from 3·12 to 4·13, whilst of six samples obtained from Cawnpur, Burdwan and Dumraon, the lowest contained 6·11 per cent. Nitrogen, the highest 8·0 per cent.; thus if these thirteen samples really represent the general quality of the cake in the respective places named, one may say that that produced on the east side of India contained just twice as much Nitrogen as that produced on the Bombay side. It is a curious case which deserves further investigation. At some of the farms castor cake has been employed as a manure for certain crops. At Poona the results of 2 years' experiments show it to be equal to poudrette, reckoned in the ratio of the Nitrogen content. At Burdwan it has been compared with cattle manure for rice and jute for several years, 6 maunds of castor cake have produced nearly as heavy a rice crop as 150 maunds of cattle manure, the amount of Nitrogen in the castor cake

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applied being probably very much less than in the dung; in the experiment with jute the outturn from the plot manured with cattle manure has been generally in excess of that from the plot to which castor cake is applied, but since the amount of plant food supplied in the castor cake was probably much less than in the cattle manure, the comparison is hardly as simple a one as might be wished.

43. ***Mahua-seed Cake*** **(Basslia latifoia)** ***and Karanji Cake*** **(Pongamia glabra).**—The seeds of both these trees are crushed and the refuse cakes form probably valuable manures. The *Mahuá* cake contains (as judged by two samples from Poona) about 2·5 per cent. of Nitrogen; the *Karanji* cake (of which four samples have been analysed) contains from 3·5 to 4·0 per cent. of Nitrogen. They are not, I believe, extensively employed as manures. At Poona they are being employed for this purpose in the sugar-cane experiments, and they have so far done very well, but the data are too few to rely on at present.

44. ***"Posta"***.—Under this name the refuse poppy-seed "heads" is known in the Cawnpur District. One sample which I have analysed contained ·77 per cent. of Nitrogen.

45. The foregoing gives an idea of the amount of oilseed and oilseed cake available in India, the amount exported as seed and in some cases the relative manurial value of the oil-cake.

Regarding the export of oil-*cake*, the returns do not particularise between different sorts, but merely give the total of all sorts exported. This was in 1889-90, 14,800 tons; in 1894-95, 23,000 tons. It is therefore, an increasing amount. At the same time the main question is, what proportion of the whole supply is being exported? In the subjoined Statement No. VI. are set out the outturn, the amount exported as seed, the amount of seed which is equivalent to the oil which is exported, and the total export of oil-cake, for those oilseeds for which estimates can be formed. **Proportion exported.**

Statement No. VI.

	Production.	Seed exported as such.	Seed equivalent to oil exported.	Oil-cake exported, 1894-95.
	Tons.	Tons.	Tons.	Tons.
Linseed	647,000	450,000	1,200	
Rape and Mustard . .	1,221,000	237,000	2,100	
Sesamum	176,000	116,000	4,000	
Cotton	992,000	4,800	...	
Earthnut	385,000	113,000	200	
	3,421,000	920,800	7,500	23,000

Of the total oilseeds contained in the above list, about one-third is exported. But of safflower, earthnut, castor, *mahuá*, *karanji* and cocoanut, the supplies of which are undoubtedly very considerable, no statistics exist which would show how much is exported and how much retained. It is very probable, however, that the proportion of these exported is very much less than in the case of those enumerated in the statement, and consequently the proportion of the oilseeds exported must be considerably less than one-third of that produced. The amount is nevertheless very large indeed and if the oil-cake could be retained it would mean a very considerable supply of food and manure which might be converted into an increase of food grains.

Uses of oil-cakes.

46. It may be urged that since some of these oil-cakes are utilised by the people as cattle food, it is a mistake to demonstrate to them their value as manures, thus inducing them in a measure to take from their cattle a part of the little extra concentrated food which they at present enjoy. There are generally two sides to a question, and the present one forms no exception to the rule. Mr. Mollison puts his view of the matter in the following terms (paragraph 15, page 30 of the Poona Farm Report for 1894-95). "There are several edible oil-cakes now used for feeding cattle in India and largely exported, which can be bought in Poona at a considerably cheaper rate per ton than the castor cake and *karanji* (Pongamia glabra) cake now so extensively employed as manure Dr. Leather's analysis proves that the edible cakes contain much higher percentages of Nitrogen (the most valuable constituent of manures) than the manure cakes, and in our extended scheme of comparative manure experiments started in the current season, the value of the edible cakes as manure is being tested. I had no hesitation in proposing this trial, because these edible oil-cakes are either exported and thus lost to the country or they are chiefly fed to milch cattle in large towns. The solid and liquid excrement of these cattle is not used as manure. The urine drains away somehow, whilst the dung is sold (in Bombay, for instance, at 8 annas a cart load) to be converted into cow-dung cakes and burnt as fuel."

Mr. Mollison's view.

47. This may prove one way of saving the oilseed cake for India. On the other hand, there can be no doubt that the true economy is to feed the edible ones to cattle and to apply the dung to the land. In this case, in addition to the albuminoids, the carbohydrates, which form the greater part of them would help by sustaining the vitality of the work cattle and the greater part, probably 90 per cent. of the Nitrogen would still go back to the land. As already pointed out, this is the economy which is practised in Europe, and it is for these two purposes that the European farmer buys these cakes, and he will probably be able to offer a higher price for them so long as the same value is not put upon them by the Indian farmer. We may be a long way from the time when this creed can be effectively taught to the Indian cultivator, but it is the one which should be professed by lecturers on agriculture, and the seed thus sown may some day bear fruit.

V.—BONES.

48. Owing to the value which bones, both in the simple ground-up condition as also in that of "Superphosphate" or "Dissolved Bone," have been found to possess in Europe for certain crops, principally Turnips and Mangel Wurzels, it has been assumed that they are of equal value to the Indian cultivator, and much has been said against their export. Unquestionably the export is large; it is probably even a large proportion of the bones annually available. The exports have, moreover, increased steadily from 18,000 tons in 1884-85 to 76,000 tons in 1894-95. The main question, however, so far as agriculture is concerned, is, what are bones worth as a manure? If they produce little or no increment to the crops of the Indian ryot, it must be admitted that there is no such want of agricultural economy as has been urged so frequently. Now fresh bones may be said to consist principally of phosphate of lime and nitrogenous substance (gelatine), they will usually contain approximately 45 to 50 per cent. of phosphate of lime and 3 to 4 per cent. of Nitrogen. It is clear, therefore, that their principal constituent is Phosphoric acid. They have been found in England to exert, when applied in moderate quantities of a few cwts. per acre, a very considerable influence on the root crops and grass lands, whilst on cereals they have exerted a much smaller influence when applied in the above indicated quantity. Of course if they be applied in larger amount, so as to supply a reasonable amount of Nitrogen, it might be expected that cereals would be benefited by them more or less.

Use of bones in Europe.

Exports.

Composition of bones.

Quantity applied as manure.

49. It is important to bear this question of quantity in mind, because one might legitimately ask, if it pays to apply oil-cakes as manures, some of which only contain about 4 per cent. Nitrogen or less, why should not bones be also applied for the sake of their Nitrogen. As a matter of fact, this question was considered when the present sugar-cane experiments were about to be instituted at Poona in 1894. Bones could then be obtained for R24 per ton, and debiting the whole cost to the Nitrogen in them, it was one of the cheapest forms of nitrogenous manure then available, and they were accordingly applied as a *nitrogenous* manure. During the following twelve months, however, the price of bones near Poona became more than double, and they could no longer be considered a cheap "nitrogenous" manure. Their market value is due to the phosphate they contain, and they can only be recommended to the Indian ryot if they are found to possess a special value for certain crops in the same way as they are found to exert a special value in England for the root or grass crops.

Increase in price.

50. A number of experiments have been made at the different farms, and it will be well to consider these in some detail.

Experiments made in India.

Rice and *kesari* (**Lathyrus sativus**) have been grown on six plots at the Dumraon Farm; three of the plots have been manured with 6 maunds (492lb) of bone meal before sowing. Statement No. VII. shows the weight of the crops, the upper part giving the outturn of paddy,

Dumraon.

the lower division that of *kesari*. With one or two exceptions, the outturns are practically the same on the unmanured as on the manured plots. The plots alternate with one another, so that the negative result from the bone manure cannot be referred to inequality of the soil.

Statement No. VII.—Showing the outturn per acre of Paddy, Grain and Straw in the experiment with bone manure.

DUMRAON.

No. of Plots.	Area in square yards.	Special treatment.	1893-94. Grain.	1893-94. Straw.	1894-95. Grain.	1894-95. Straw.
			℔	℔	℔	℔
13	800	Bone manure at 6 maunds per acre.	806	1,474	837	1,668
15	800		831	1,424	827	1,125
17	800		793	1,474	855	1,125
		Average outturn . .	810	1,457	839	1,305
14	800	Unmanured . .	819	1,449	1,333	2,849
16	800		793	1,363	840	1,531
18	800		855	1,351	883	1,665
		Average outturn . .	822	1,387	1,018	2,015

Statement showing the outturn of Kesari, Grain and Straw in the experiment with bone manure.

DUMRAON.

No. of Plots.	Area in square yards.	Special treatment.	1893-94. Grain.	1893-94. Straw.	1894-95. Grain.	1894-95. Straw.
			℔	℔	℔	℔
13	800	No additional manure	1,240	1,363	1,117	1,257
15	800		1,134	1,153	1,073	1,240
17	800		905	967	1,101	1,411
		Average outturn . .	1,093	1,161	1,097	1,302
14	800	Unmanured . .	1,166	1,214	1,382	1,819
16	800		1,066	1,104	1,364	1,759
18	800		892	930	1,365	1,812
		Average outturn . .	1,041	1,082	1,370	1,797

Dumraon.

(2) In another experiment at the same farm wheat has been grown on five plots of land; one received no manure, two have had 6 maunds of bone meal, and two 6 maunds of bone meal and 3 maunds of

saltpetre. Statement No. VIII. exhibits the results. It is seen that the outturn on the plots to which bones were applied is rather less than where no manure at all was used, though the difference is not greater than one would expect to find from two different plots quite irrespective of any manurial treatment. From the two plots to which saltpetre was applied in addition to the bone meal the outturn was very much larger. Thus, so far as this experiment goes, there is no doubt that bones produced no increase, whilst saltpetre added about 30 per cent. to the outturn.

Statement No. VIII.—Showing outturn per acre of Wheat in the experiment with bone meal.

DUMRAON.

No. of Plots.	Area in square yards.	Special treatment.	1894-95. Grain.	1894-95. Straw.
			℔	℔
31	800	No manure	402	701
28	800	Bone meal at 6 maunds per acre.	394	692
30	800		390	682
		Mean .	392	687
27	800	Bone meal, 6 maunds, and Saltpetre, 3 maunds, per acre.	523	880
29	800		544	927
		Mean .	533	903

(3) At the Burdwan Farm two plots have been manured with bones and two plots left unmanured, the crop grown being rice. Statement No. IX. contains the results. In this case the bone meal has produced a very considerable increase in the crop, which has been more than double on the manured than on the unmanured land. Burdwan.

(4) In another experiment (*vide* Statement No. X.) at the same farm, bone meal, and cattle manure have been applied for the jute crop; one plot has remained without manure. Regarding the rates at which the manures have been applied, the cattle manure has probably contained far more Nitrogen and considerably less phosphates than the bone meal. The bone meal has only produced about as much jute per acre as was obtained from the unmanured land *at first.* After bearing three crops, this unmanured land failed to produce a crop at all. There is no such decrease in productive power observable in the case of the land manured with bones, and it is probable that they have at any rate kept the land up to its normal standard. But a much greater yield has been obtained from the cattle manure which must be referred to the Nitrogen it contains, since the amount of Phosphoric acid has probably been much less than that supplied by the bones.

Statement No. IX.—Burdwan Farm—Paddy.

Number of Plots.	Area in Cottahs.	Treatment with reference to manure. Quantity applied per acre.	Outturn per acre. 1891-92. Grain.	1891-92. Straw.	1892-93. Grain.	1892-93. Straw.	1893-94. Grain.	1893-94. Straw.	1894-95. Grain.	1894-95. Straw.
			℔	℔	℔	℔	℔	℔	℔	℔
68*b*	9	Unmanured	1,799	2,662	1,255	1,666	1,646	3,291	1,467	2,743
69*b*	9	Bone meal, 3 maunds	3,838	4,722	3,703	4,937	4,521	6,295	3,826	5,993
70*b*	9	Bone meal, 3 maunds	3,914	4,758	3,826	4,937	3.703	5,801	4,637	6,267
71*b*	9	Unmanured	1,892	2,748	1,481	2,469	1,786	2,332	1,574	2,061

Statement No. X.—Burdwan Farm—Jute.

Number of Plots.	Area in Cottahs.	Treatment with reference to manure. Quantity applied per acre.	Outturn per acre. 1889-90.	1890-91.	1891-92.	1892-93.	1893-94.	1894-95.
56*a*	4¼	Bone meal, 3 maunds	...	...	...	1,220	1,191	1,220
56*b*	6¼	Cow dung, 150 maunds	2,333	2,488	1,382	1,679	1,777	1,721
56*a*	2½	Unmanured	1,234	1,306	686	Failed.	Failed.	Failed.

M. 237-59.

Poona.

(5) At Poona in the sugar-cane experiments bones and bone superphosphate are applied to two plots, and these manures *plus* saltpetre are applied to two others; only the first year's outturns are published, and these are given in Statement No. XI. for the four plots which are manured with bones.

The weight of sugar from the plots manured with bones, bone superphosphate and bones and saltpetre are far below what was obtained with poudrette and oil-cakes; that from the plot receiving superphosphate and saltpetre about equalled these. But the cost of such large applications of bones is now quite prohibitive, and it has become necessary to reduce the quantity very materially.

The large outturn from Plot 11 is possibly due to the Nitrogen in the superphosphate being in a more readily available form. It will be observed that from bones the lowest outturn is obtained; then a larger outturn is obtained from bones and saltpetre and bone superphosphate, both containing more readily available Nitrogen than in the bones alone, and the highest yield is obtained from the dissolved bones and saltpetre in which the amount of readily available Nitrogen was the highest. In any case the large amount of Phosphoric acid has not shown itself of any advantage.

Statement No. XI.—Comparative Manures—Plots $\frac{1}{5}$ acre each— POONA.

No. of Plot.	Kind of manure.	1894-95. Weight of manure per acre.	Nitrogen per acre.	Weight of *gul* per acre.
		Tons.	℔	℔
4	Bone meal	5	420	6,945
5	Dissolved bones	6	434	9,870
10	Bone meal and saltpetre	{ 2·5 1·0	210 207 } 417	9,975
11	Dissolved bones and saltpetre	{ 3 1	217 107 } 424	13,225
12	Poudrette	42	847	13,270

Nagpur.

(6) At the Nagpur Farm, wheat has been grown on two series of plots with different manures. The plots of each series correspond in the matter of manuring and cultivation, the only difference being that Series A is *not* irrigated artificially, whilst Series B *is* irrigated.

For Series A we have 10 years' results and the averages of the first and second five-year periods occupy the first part of Statement No. XII.; the Series B was commenced in 1890, and we have only five years' results, the mean of these being placed in the second portion of the statement. The result of these experiments is fairly uniform throughout. From an application of 360℔ of bone-dust there has been

obtained hardly any increase over the outturn of the unmanured plot, from the plot to which saltpetre is applied a very considerable increase is obtained, whilst when we add the bones to the saltpetre, only a slight further increase is obtained, due probably to the Nitrogen of the bones.

Statement No. XII.—Experiments on the value of manures for wheat, NAGPUR.

Area of each plot—0·10 acre.

No. of Plot.	Kind of Manure.	Series A, Unirrigated. Outturn per Acre. Average of five years, 1885-89. Grain.	Straw.	Series A, Unirrigated. Outturn per Acre. Average of five years, 1890-94. Grain.	Straw.	Series B, Irrigated. Outturn per Acre. Average of five years, 1890-94. Grain.	Straw.
7	Unmanured	799	1,297	418	796	486	820
2	Bone-dust, 360lb per acre . .	891	1,388	534	882	626	954
1	Saltpetre, 240lb per acre . .	1,133	1,711	751	1,468	931	1,789
3	Saltpetre, 240lb and bone-dust, 360lb per acre.	1,094	1,751	865	1,538	1,012	1,924

M. 237-59.

(7) At the Cawnpur Farm four series of plots are employed to test the value of different manures for the wheat and maize crops. On one series of 13 plots wheat is grown every year, on a second series of 13 plots maize is grown annually; on the remaining two series of 13 plots each maize and wheat are grown in alternate years, wheat being grown on one series in the same year as maize is grown on the other series. The manures for the corresponding plots of each of the four series are the same, thus Plot No. 1 of each series is manured with cow-dung and bone-dust every year just before the particular crop is sown. There is no plot which is manured with bone meal *alone*, but the value of bones is discernible from the comparative results of certain plots which are supplied with bones and cattle manure and bones and sheep-dung. In the Statement No. XIII. are set out the mean outturns of maize and wheat obtained on certain of the plots. The experiments have been in progress for 14 years, but only the last 12 years are suitable for drawing conclusions from; also in 1887 and 1888 the maize was a failure and these years have been excluded for that crop, and as the Plot No. 10 was only included in the experiments in 1884, the results obtained on plot No. 7 are taken for the same 9 years in the case of maize and for the same 11 years in the case of wheat as are available for Plot No. 10. Plot No. 3 is comparable with No. 1; Plot No. 10 may be compared with No. 7, since in each case bone meal is applied in addition to the dung on one of the pairs. Plot No. 6 compared with No. 5 shows the value of bone superphosphate. It will be seen that the bone meal applied to Plot No. 1 in addition to dung has increased the maize crop on both series of plots; in the case of wheat, the crop has been increased on the "Standard" series of plots, whilst there has been a decrease on the "Duplicate" Series. The results obtained with bone meal on Plot No. 7 is less regular, there has been an increased outturn of maize on the "Standard" Series, and a decrease on the "Duplicate"; likewise in the case of wheat there has been a less outturn on the average on the "Standard" Series, and an increased outturn on the "Duplicate" where bone meal has been added to the dung. Of course, strictly speaking, there should have been at least as much grain obtained where bone meal was applied as where it was not applied, but in such experiments as these, and especially when one deals with a manure of such variable nature as cattle dung, exact results cannot be expected. On the whole, whilst there is some evidence that bone meal has added to the crops, the gain has not been very great.

Turning now to the third pair of plots, on one of which 3 maunds of saltpetre, on the other 3 maunds of saltpetre *plus* 3 maunds of bone superphosphate has been applied, it is seen that the superphosphate has uniformly increased the crop, though here also the gain is not great. Superphosphate is, moreover, very expensive in India at present. It may be safely asserted that the same quantity of bones (as superphosphate), would have produced a very much larger return had it been employed for root crops in Europe.

Statement No. XIII.—Cawnpur Experiments.

No. of Plot.	Manure employed.	Maize.		Wheat.	
		Average of 10 years, 1883-86; 1889-94, "Standard" Series of plots.	Average of 10 years, 1883-86; 1889-94, "Duplicate" Series of plots.	Average of 12 years, 1883-84 to 1894-95, "Standard" Series of plots.	Average of 12 years, 1883-84 to 1894-95 "Duplicate" Series of plots.
		℔	℔	℔	℔
3	Cattle Dung, 180 maunds . . .	1,103	931	1,419	1,705
1	Cattle Dung, 180 maunds and Bones, 4½ maunds.	1,372	1,007	1,506	1,600
10	Sheep Dung, 180 maunds . . .	*1,128	*1,270	†1,476	†1,607
7	Sheep Dung, 180 maunds and Bones, 4½ maunds.	*1,364	*1,045	†1,404	†1,644
5	Saltpetre, 3 maunds	946	767	1,402	1,602
6	Saltpetre, 3 maunds and Bone Superphosphate, 3 maunds.	1,131	874	1,477	1,749

* Average of 9 years.
† Average of 11 years.

Indeed it is doubtful whether it would pay the Indian cultivator to grind up the bones to use as manure for cereals, for this will cost fully R1 per maund.

51. The results obtained at the different farms, excepting the single case of the rice crop at Burdwan, show that the increased outturn of cereals is but very small, it is doubtful if one can depend on a definite increase at all. This is also in accordance with the lesson which the Rothamsted and Woburn experiments have taught in England, namely, that it is the root crop which will respond largely to an application of phosphates, whilst cereals are particularly benefited by one of Nitrogen ; and here in India the experiments uniformly show that the cereals and millets are similarly benefited by a nitrogenous manure. It may be also added that, so far as the experiments have gone, there is fairly uniform evidence indicating that the same holds good for sugar-cane. Until, therefore, we find that bones are of *considerable* value to some particular crop in India, it can hardly be said that their export constitutes any serious loss to the ryot. It is not suggested that further experiments on the manurial value of bones should be discontinued. On the contrary, experiments are being commenced to test their value for both oilseeds and potatoes, and roots will also be included as soon as the necessary arrangements can be made. Oilseeds and potatoes are largely cultivated ; swedes are extensively grown in the Panjab, and carrots are grown commonly in the North-Western Provinces.

VI.—SALTPETRE.

52. The value of saltpetre as a manure is well recognised in Europe, and if its virtue in this respect is not also known in India, it is certainly applied *indirectly* as a manure. There is hardly any need to go into details of its value in this place. In *The Agricultural Ledger No. 14 of 1895* (Medical and Chemical Series, No. 2) is set out the composition of a number of well waters, from Gujerat (Bombay) containing high proportions of nitrates which are known to the people to be of great value to the tobacco crop, and the water is annually sold at certain rates by the proprietors of the particular wells.

Saltpetre has also proved itself at the farms to be a valuable manure. Its value is probably almost entirely due to the Nitrogen it contains. I have not found Indian soils wanting in potash. One or two analyses of the saltpetre generally met with in the bazars may be here appropriately quoted. Composition.

Statement No. XIV.—Composition of Samples of Saltpetre.

Moisture	5·80	11·87	1·55	·60
Nitrate of Potash	48·90	35·01	94·91	94·80
Sodium Chloride	30·82	26·94	1·93	3·83
Sodium Sulphate, etc.	10·53	14·90	1·21	·57
Sand	3·95	11·28	·40	·20

The greater number of samples, which I have analysed, are decidedly impure and usually contain a lot of common salt with a little sulphate. The first and second analyses in the statement represent two samples of *very* low quality, the third and fourth two of very high quality. The price and purity of saltpetre vary considerably in different places, sometimes it can be bought for R3 per maund, sometimes it will cost R10, the price being generally (though not always) indicative of the purity.

Price.

For example, two samples obtained at Poona this year were priced at R8-4 and R8 per maund, while they contained 86 and 60 per cent. of nitrate of potash respectively. It is in any case a very dear manure; its Nitrogen costs about three times as much as the Nitrogen in some oil-cakes or in poudrette.

Village nitre-earth.

53. ***Village Nitre-earth.***—It is probable that in villages generally saltpetre forms in the gutters and wherever drainage collects, and nitrification can proceed. Saltpetre is frequently extracted from this, but in other cases this earth is applied as a manure. Three samples of nitre earth, which I have received from Cawnpur, contained 2·52 per cent., 2·90 per cent., and 2·18 per cent. of nitrate of potash.

VII.—THE SILT OF RIVERS, CANALS AND TANKS.

54. There is probably no more generally applied "manure" in India than the silt of rivers and canals, and of tanks also where they are common. The term "manure" must be admitted here, because its meaning may be said to be essentially "an application of plant food to the soil," although, on the other hand, the amount of that plant food which silt contains in a given weight is very small compared with most other "manures." When one bears in mind the very remarkable part which water plays in many parts of India during the monsoon periods, when the surface wash, whether from hill sides or from more level lands, is so great that clear water is not to be seen, it will be apparent that vast quantities of earth of one description or another are transported, and in part deposited at lower levels. In some cases an absolute loss to the cultivator occurs, in others he is the gainer. It is not a part of the object of this paper to enter upon this transference of soil, excepting with the one purpose of illustrating how it may become an agent for enriching the land.

In the first place since India generally has only a comparatively small supply of manures, even poor ones are of advantage in at least assisting to maintain the fertility of the soil. Especially in the case of canals is this deposition of silt a regular feature. Rivers more frequently take silt *from* the cultivated lands, but in those parts where they either flood the country annually as in Eastern Bengal, as likewise where they are dammed up and brought over the land by the people, as in some of the Eastern Districts of the North-Western Provinces, they *must* be adding to its fertility. Where tanks are employed as irrigation agents the mud which collects in them has been transported from the hills and is frequently dug out and

applied to the land as a fertiliser. At the same time *all* silt carried by rivers is not a blessing. If it consists principally of sand, it will probably do harm rather than good. Such, for instance, is the case in the Hoshiarpur District of the Panjab, where enormous amounts of sand are brought down from the hills during the monsoon and cover up the good soil. Exact information as to the agricultural value of silt is almost entirely wanting. Some experiments are at present being made to estimate the value of silt brought on to the land by canal water, and the first year's results have gone to show that the amount of plant foods, Nitrogen and Phosphoric acid, in the silt of the Eastern Jumna canal water is more than is taken from the soil by the rice crop, but is considerably less than what an average wheat crop will take up and very far less than what a sugar-cane crop requires. Incidentally this result coincides with the general practice in regard to rice cultivation in India. Rice lands are rarely manured. They are usually clays, and the water passes from one field to another, removing and also, at the same time, depositing silt. Thus rice lands may be said to annually receive a certain amount of silt from higher levels, and this may prove to be an explanation of why they can do without manure better than any other sort of lands.*

Agricultural value of silt.

Rice lands.

VIII.—GREEN MANURING.

55. If a crop be grown and then, whilst green and immature, it be ploughed in, the land will be enriched with organic material, and rendered more open and its quality may be thereby improved for a succeeding crop. This process is styled "green manuring." Indian soils are so generally poor in organic matter that it may be said the process is especially beneficial to them. Another advantage probably accrues, for whilst a crop is growing, some portion of its plant food will come from sources which are considered "less available," *i.e.*, less readily assimilated than that which is "readily available," and when the plant is destroyed and it decays, this plant food, which may be said to have been obtained with difficulty by the green crop, will be readily "available" to the succeeding one. Thirdly, the green crop will take nutriment from the sub-soil, and this will be deposited at the surface when the crop is "ploughed in." Thus in such a case it may be said that the green crop adds organic material to the soil, increases the readily available plant food and carries plant food from the sub-soil to the surface; a point of some value to the young plant. If the green crop belong to the sub-order PAPILIONACEÆ (nat. order LEGUMINOSÆ) it is probable that it will, in addition to the above, effect an absolute increase not only of carbonaceous matter, but likewise of Nitrogen from the atmosphere. This property of the pea family of plants has been sufficiently fully dealt with in *The Agricultural Ledger No. 7 of 1894* (Agricultural Series, No. 8), and requires no further explanation here.

Objects added organic materials.

Increase of available plant food.

Plant food brought from sub-soil.

Assimilation of atmospheric Nitrogen.

* *Note.*—Since writing the above the details of the experiments with canal silt have been published in *The Agricultural Ledger No. 5 of 1897*—*J. W. L.*

Agricultural experiments.

Experiments to test the value of the process of ploughing-in green crops have been in progress at the Cawnpur and Nagpur Farms for a number of years, and the principal results have been published in *The Agricultural Ledger No. 3 of 1894* (Agricultural Series, No. 7, pages 8 to 12). The results of two more years are now obtainable, but no good purpose would be fulfilled by recapitulating them. It need only be stated that these newer figures corroborate those referred to (*l. c.*) at Cawnpur, and since the attacks of rust have not been severe at Nagpur during the two additional years (1893-94 and 1894-95), the results obtained at that farm are more concordant than they were. Much will naturally depend on whether the "green crop" grows well or not. If it is more or less of a failure, its value as a manure will naturally be small. At Cawnpur the increase in the wheat crop due to this system of manuring has generally been several hundred pounds per acre; at Nagpur it has varied much according to whether the wheat has been affected by rust or not, but in the years of good wheat harvest, the increase has amounted to between 100 and 200℔ of grain. How far this method of manuring is practicable to the ordinary cultivator is, however, a question which cannot be said to have been answered altogether. The practice is adopted in some places.

IX.—THE ASSIMILATION OF NITROGEN BY PAPILIONACEÆ.

Conf., Agricultural Ledger No. 7 of 1894.

Cawnpur experiments.

56. In paragraph 60 of Dr. Voelcker's Report on the Improvement of Indian Agriculture it is pointed out how extensive is the cultivation of plants of the leguminous order, and the question is raised as to how far their presence is assisting to maintain the supply of Nitrogen to the soils of India. Experiments have been in progress at the Cawnpur Farm for about 15 years to test the effect of the indigo and *san* hemp crops in this respect. The crops are grown in the monsoon, then removed, and wheat is then sown on the same plots in the following *rabi*. The results with *san* hemp are so discordant as to become valueless; those for indigo are better, and are contained in Statement No. XV.

Statement No. XV.—Experiments to test the value of Indigo for the succeeding Wheat crop—Outturn of grain in ℔.

	1883-84.	1884-85.	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.	1891-92.	1893-94.	1894-95.
Wheat after Indigo .	1,590	1,107	1,791	1,283	1,379	835	1,988	1,136	1,258	696	287
Unmanured.	1,514	623	1,367	847	786	653	1,464	1,162	690	877	287
Increase (or decrease)	+76	+484	+424	+434	+593	+182	+524	—26	+568	—181	...

M. 237-59.

It is seen that, so far as this experiment goes, there is a very considerable increase in the greater number of years. Indigo planters generally, I believe, recognise that the crop is beneficial to the succeeding wheat, and it is possible that the results of the above experiment are not accidental. At the same time they require very careful verification, because if they do not overstate the case, one would have thought the cultivator would have found out the great value of the process and applied it generally for wheat. Similar experiments are being made with several other papilionaceous crops at Cawnpur, but no results are available at present.

X.—SHEEP FOLDING.

57. The practice of penning sheep and goats on cultivated land with the object of manuring it for a succeeding crop is practised extensively in some parts of India, especially in Bombay and Madras Presidencies. It is a most valuable method and it is common (I believe) for cultivators to pay the herdsmen to keep their flocks on the land. Precise information of the practice is, however, not in my possession.

CONCLUSION.

58. In the foregoing paragraphs such information regarding the properties of the various "manures" which are (or might be) available to the cultivator, as is at the writer's disposal, has been set out; the chemical composition has been explained, and the results of growing certain crops experimentally with these manures have been stated. There still remains one point, namely, the *quantity* of these several substances, about which a few words may be said in conclusion. Incidentally figures have been stated when dealing with the several materials indicating quantities per acre or, as in the case of oilseeds and bones, the amounts exported.

One might go further and calculate from the approximate weight and composition of the various crops grown, the probable amount of fertilising matters which the various manures will be equivalent to. The data are, however, not very exact, and it is, perhaps, unnecessary. In paragraph 1 it is stated that the manure supply of India must be considered as obtainable, for all practical purposes, from materials produced *in* India. The only "manure" which comes from outside is the silt brought by rivers and canals, whilst this source of plant food is not very small in amount, it is but little when compared with the whole. The area irrigated by canals is 10,900,000 acres, that from rivers, tanks, etc., 7,300,000 (*vide* Statistical Atlas of India), both of which are sources of silt deposit. The total cultivated area is 220,000,000 acres, so that less than one-tenth of the cultivated area is thus more or less replenished from outside.

But for the rest, it must depend on *the simple return*, more or less perfectly carried out, *of the plant food which the crops grown, extract from the soil.* If this fact be borne in mind, it must be admitted

that *the* principal source of manure *must* be the excrements of the people and animals. It *may* be that the leguminous plants are exerting a material influence, and this is a subject very well worth careful investigation both in the field and in the laboratory. At present we do not know even which plants of this natural order assimilate Nitrogen and which (if any) do not. Much less complete is our information regarding the comparative powers of these plants to assimilate this plant food. The exports of oilseeds, bones, etc., must in any case be admitted to fall into insignificance by the side of the various animal manures. It is the more perfect recovery of these excrementitious matters which will gradually increase the manure supply generally, and it is in this direction that the most useful work may be done. Whether a better fuel supply can be gradually produced so as to save the cattle dung; whether the urine may be more readily collected for direct return to the land; whether night soil and sweepings may be applied to larger areas than is at present the case, may be said to be really the main questions which require practically working out.

M. 237-59.

G. I. C. P. O.—No. 246 A. & R. D.—6-8-97—2,200—W. B. G.

(Vegetable Product Series, No. 35.)
(Timbers.)

THE

AGRICULTURAL LEDGER.

1897—No. 9.

LAGERSTRŒMIA FLOS-REGINÆ.

(JARÚL.)

[*Dictionary of Economic Products, Vol. IV.*, L. 42-49.]

A brief account of existing information amplified by details obtained through Officers of the Indian Forest Department, and a recent report by PROFESSOR W. C. UNWIN, F.R.S., *on Mechanical Tests of the Timber at the Imperial Institute, London. The whole forming a Revision of the Dictionary Article on the subject.*

The following article on **Lagerstrœmia Flos-reginæ** has been drawn up mainly from information received from the various Forest Officers of India, in reply to a series of questions issued by this office in the form of a Circular Note. This course was pursued in accordance with arrangements that had been made with the Inspector General of Forests for the investigation each year of two or three forest trees in the timbers of which it might be thought there was a possibility of the export trade being extended or established. The primary object of the enquiry was thus the trade in the timber of each species, but opportunity was taken to collect particulars as to the area of distribution of the tree, the nature of the forests in which it occurred, the conditions of soil and climate under which it luxuriated and the minor economic products which it afforded. Such an enquiry necessarily meant a complete revision and confirmation of the particulars already published in the *Dictionary of the Economic Products of India*, and it has accordingly been thought the more desirable course to throw the new information into the form of a revised version of the Dictionary article.

The numbers shown on the margin are the registration numbers assigned to the specimens collected as the result of this enquiry.

LAGERSTRŒMIA, *Linn.; Gen. Pl., I., 783.*

A genus of trees or shrubs which belongs to the Natural Order LYTHRACEÆ. It comprises 18 species, natives of South-East Asia, extending to Australia. Burma is the centre of the genus. All the species are highly ornamental, and may be either propagated in garden soil by seed, or by cuttings.

Lagerstrœmia Flos-reginæ, *Retz.; Fl. Br. Ind., II., 577; Wight, Ic., t. 413; Index Kewensis, Pt. III., 23;* LYTHRACEÆ.

Syn.—ADAMBEA GLABRA, *Lamk.;* L. AUGUSTA, *Wall.;* L. MACROCARPA, *Wall.;* L. MAJOR, *Retz.;* L. MINOR, *Retz.;* L. MUNCHAUSIA, *Willd.;* L. PLICIFOLIA, *Stokes;* L. REGINÆ, *Roxb.;* L. SPECIOSA, *Pers.;* MUNCHAUSIA SPECIOSA, *Linn.*

Vern.—*Arjuna, jarúl,* HIND.; *Járul,* BENG.; *Gara saikre,* KOL.; *Sekra,* SANTAL; *Ajhar, jarul,* ASSAM; *Bolashari, jalai,* GARO; *Taman, tamána bondara,* BOMB.; *Bondara, mota-bondara,* KONKAN; *Taman, tamana, mota-bondara, tamhena,* MAR.; *Kadali,* TAM.; *Chennangi,* TEL.; *Challá, holedasál, holedasalu, holehonagalu, holemathi, hole pavase, maruva,* KAN.; *Adambœ,* MALAY.; *Eikhmwé, konepyinma, léza, lézani, pyinma, yengma,* BURM.; *Kamaung,* MAGH.; *Murute, murutagass,* SING.; *Arjuna,* SANS.

References.—*Roxb., Fl. Ind., Ed. C.B.C., 404; Brandis, For. Fl., 240; Kurz, For. Fl. Burm., I., 524; Beddome, Fl. Sylv., t. 29; Gamble, Man. Timb., 202, 203; Dalz. & Gibs., Bomb. Fl., 98; Mason, Burma and Its People, 406, 537, 538, 758; Sir W. Elliot, Fl. Andh., 36; Works of Sir W. Jones, V., 147; Smith, Dic., 55; Lisboa, U. Pl. Bomb., 80; Birdwood, Bomb. Prod., 330; Talbot, List of Trees, Shrubs and Climbers, Bomb., 99; Forest Trees, Mysore and Coorg, 3rd ed. by John Cameron, 149, 150; Kew Reports, 69; Suggestions* re *Forest Adm., Madras, 1883, 62; Working Plans, Central Colaba, Bomb., 1894 and 1895, 209; Note on Inspection of Forests, Assam, 1889, 14, 25; Working Plans, Goalpara Sál Forests, Assam, 1894, 5; Suggestions* re *Forest Adm., Br. Burma, 1881, 9, 56; Working Plan for Kobaung Reserve, Toungoo Dn., 1894, 3; Gazetteers:—Bombay, X., 37, 404; XI., 26; XIII., 24; XV., 37, 70; Burma, 1879-80, I., 83, 85, 87, 109, 118, 125, 135; II., 5, 6, 129, 136, 164, 168, 186, 201, 213, 223, 257, 268, 270, 275, 300, 325, 437, 441, 534, 612, 650, 686, 706, 788, 816, 817, 854; Mysore and Coorg, I., 47, 61; Imperial Gazetteer, I., 349; Agri.-Horti.-Soc. of Ind., Journal (Old Series), IV., 128, 134, 208, VI., 41; VIII., Sel., 177; IX., 252, 423; XI., 446; XIII., 336; Indian Forester, I., 112, 363; II., 19; III., 23; IV., 47, 101; V., 190, 497; VII., 42, 196; VIII., 381; 402, 414; IX., 358; X., 33, 134, 532; XI., 258, 288, 320, 321, 374, 375; XIII., 127, 376, 553; XIV., 119, 339; Letters, No. B. 694, dated 25th March 1896, from Asst. Conserv., Forests, Sibsagar Div.; No. B. 55, dated 7th May 1896, from Offg. Dy. Conserv., Forests, Garo Hills Div.; No. B. 211, dated 15th July 1896, from Dy. Conserv., Forests, Cachar Div.; No. T. E. 245, dated 27th November 1896, from Conserv., Forests, Assam; No. B. 632, dated 17th January 1897, from Asst. Conserv., Forests, Sibsagar Div.; No. 2504, dated 23rd March 1896, from Divl. Forest Officer, N. D. Kanara; No. 155, dated 14th an*

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April 1896, from Dist. Forest Officer, Poona; No. G. 154, dated 25th June 1896, from Divl. Forest Officer, Kolaba; No. G. 340, dated 2nd September 1896, from Divl. Forest Officer, Kolaba; No. 84—21 G. R., dated 24th March 1896, from Dy. Conserv., Forests, Katha Div., Burma; No. 831—36 A.—2, dated 11th July 1896, from Conserv., Forests, E. Circle, Burma; No. 149 J.-6, dated 14th August 1896, from Dy. Conserv., Forests, Prome Div.; No. 2893—54-2, dated 26th January 1897, from Conserv., Forests, Pegu Circle, Burma; No. 378 For., dated 21st September 1896, from Dist. Forest Officer, S. Canara; Imp. Inst. Journal, II., 1896, p. 444; Progress Report of Forest Administration of Assam, 1895-96, p. 14.

Habitat.—A large deciduous tree often attaining a height of 150 feet with a girth of 6 to 12 feet and a bole extending from 15 to 40 feet. It is found in abundance in Assam and Burma, and less plentifully in the Bombay and Madras Presidencies. Cultivated throughout India as an avenue tree.

Cultivation.—The tree is reported by all the Forest Officers as growing wild, no special care being taken to propagate it. The following information has been collected regarding its reproduction:—" Natural reproduction is not good as the tree grows on low and swampy ground with a dense undergrowth which precludes all possibility of seed germinating" (*Lakhimpur*); "It grows wild, no special care being taken to propagate it, as it reproduces itself (on low land) most luxuriantly every year, seeding most abundantly" (*Sibsagar*); "It is never cultivated but reproduces itself naturally from seed" (*Prome*). It is reported from Burma, Katha Division, as being associated with teak. In the *Progress Report of Forest Administration in Assam, 1895-96, p. 14*, it is referred to as follows:—" Under cultural operations the additions shown are 79 acres of *jarúl* (**Lagerstrœmia Flos-reginæ**) in the Langai and Singla reserve, Sylhet Division, which includes 6 acres of the year and 73 acres previously established and 7 acres of established *jarúl* sown on *jhúms* in the Bagmara reserve, Garo Hills Division." Period of sowing seeds early in May (*Garo Hills*). **Seeds. Reg. No. 8533.**

Soil.—It is reported as being "a very accommodating tree as regards soil requirements, stiff clays and rich deep loams seem both to suit it" (*Sibsagar*). By the majority of the correspondents the tree has been observed to flourish on flat and low-lying swampy ground, in places where vegetation is abundant and atmospheric conditions moist, and on the banks of streams. The Forest Officer of Sibsagar further writes as follows:—" It grows principally on low-lying swampy ground, inundation for a portion of the year appearing to be favourable to its growth. It, however, appears, though does not thrive on high ground or on *teelas* (low hills)." The Bassein Forest Officer says: "flourishes on rather high ground." The Forest Officer of the Katha Division, Burma, reports it as flourishing in well-drained localities. It is fit to be felled at 30-50 years of age.

Peculiarity regarding Growth.—It very rarely has a clean, straight bole to any great height, its branches almost invariably, having a

tendency to a low downward growth. Both the stem and branches are as a rule much knotted and twisted.

Flowers. Reg. No. 8005. 8523. 8531. 9303.

Flowers.—It bears large purple or mauve-coloured flowers which are discernable from a great distance. During the period of flowering the country side is a mass of purple or mauve colour, due to the frequent occurrence of the tree. The flowers appear between March and July. On account of its ornamental appearance it is cultivated all over the hotter parts of India, as far north even as Lahore.

Fruits. Reg. No. 8521. 8532. 8704. 9145. 9302.

Fruits.—The fruits ripen in July and August. The Forest Officer, Prome, states that the fruits in his district ripen in December. "The seeds form in August and September, and do not fall till the following May" (*Sibsagar Forest Officer*).

Leaves.—"Appear in May and fall off in February and March" (*Sibsagar*).

Resin.—"Exudes a resin" (*Kurz*). All the information that has been received from the Forest Officers on this point can be summed up in these few words: "Not collected nor used." Only two officers, those of Sibsagar and South Canara, assert that the tree does not exude any resin. The point is still therefore doubtful whether or not it affords a gum.

Fibre. Reg. No. 8178.

Fibre.—The Forest Officer of Kheri, Oudh, supplied a sample of the FIBRE. Specimens were not furnished from any other source and the fact that **Lagerstrœmia Flos-reginæ** yielded a fibre appears to have hitherto escaped notice. There is no record of the fibre being put to any use.

Roots. Reg. No. 8002. 8007. 8520. 8528. 8661. 8701. 9148. 9301.

Medicine.—The root is prescribed as an astringent. "Its ROOT, BARK, LEAVES and FLOWERS are used medicinally by natives" (*Beddome*). The **Rev. J. Long** in an article on the Indigenous Plants of Bengal, states that the SEEDS are narcotic, the bark and leaves purgative (*Jour. Agri.-Hort. Soc. of Ind.* (*Old Series*), *IX.*, *423*). **Dr. Thomson** reports, that the fruit of the *Pyenma* is used in the Andamans as a local application for aphthæ of the mouth (*Jour. Agri.-Hort. Soc. of Ind.* (*Old Series*), *XI.*, *446*). The Forest Officer of Prome, Burma, writes that the bark is pounded up and used by the Burmese medicine men in fever cases. The replies from the Forest Officers of Assam, Bengal, and Madras are to the effect that no parts of the tree are used as medicine.

Bark. Reg. No. 8003. 8008. 8179. 8519. 8529. 8660. 8703. 9147. 9300.

SPECIAL OPINION.—§ "The bark of this and of **L. indica**, *Linn.*, is considered stimulant and febrifuge" (*Surgeon-Major W. D. Stewart, Cuttack*).

Leaves. Reg. No. 8004. 8009. 8180. 8522. 8530. 8662. 8702. 9146. 9304.

Structure and Uses of the Wood (sometimes called Indian Blood Wood).—"Shining, light red, hard; annual rings marked by a belt of large pores, weight about 40lb per cubic foot. This is the most valuable timber of Sylhet, Cachar, and Chittagong, and in Burma the next in value after teak. It is used in ship-building, and for boats and canoes, all kinds of construction, timber and carts. The Ordnance Department use it for many parts of their gun-carriages. In South India it is used for building, and in Ceylon for casks" (*Gamble*). **Kurz** describes the wood as being pale or dark brown, rather heavy, streaked, fibrous but close grained, takes a fine polish. In

Timber (Cachar). Reg. No. 8046.

Burma it is used for house posts, planking, beams, scantling for roofs, carts, boats, paddles, oars, etc. **Beddome** states that it is very durable under water, though it soon decays under ground, also that, in his time, it was employed at the Madras Gun-carriage manufactory for light and heavy checks, felloes, and cart naves, framing and boards of wagons, timbers, ammunition box boards, and platform carts.

Timber (Burma). Reg. No. 8342. Timber (South India). Reg. No. 8658. 8659. 9124. 9299.

At a conference held on timbers, at the Colonial and Indian Exhibition in 1886, it was recommended to carriage-makers in England, and the suggestion offered that it might be exported from Calcutta, Chittagong, Rangoon, and Madras. The chief supply comes from the forests of Assam and Cachar, and the timber would, therefore, be procurable most readily from Calcutta.

Timber (Assam). Reg. No. 8593. 8594.

The opinions of the various Forest Officers prove it to be of excellent quality, hard, lasting well when subject to changes of moist to dry weather, very durable under water, able to stand rough wear, and thus very valuable. It is used for purposes of house and boat building, for bridges, carts, and in fact for every kind of work where hard, easily workable, and durable timber is needed. It is in considerable demand in Assam as keel pieces for boats that have to pass through salt water, as it is said to resist the action of salt water better than any other timber. At an enquiry as to the best substitute for Italian Walnut for use as rifle stocks it was recommended by the Inspector General of Forests as the best in his opinion for that purpose.

Timber (South Canara). Reg. No. 9299.

As somewhat opposed to the above statement of its merits the Forest Officer of South Canara reported as follows:—"The wood is soft and light; white in colour. Takes polish well and the timber is said to be free from shakes and cracks. It is, however, said to be so liable to attack by white-ants that it is not used for any building purposes nor in any shape whatever." The confliction of opinion may be due to the timber attaining a better quality in Assam than elsewhere.

A recent report on mechanical tests of this timber by **Professor W. C. Unwin, F.R.S.**, at the Imperial Institute, London, may be here given:—

REPORT ON MECHANICAL TESTS OF AN INDIAN TIMBER.

(By Professor W. C. Unwin, F.R.S., etc.)

The plank dealt with, which was about $2\frac{3}{4}$ inches thick and rather exceptionally dry (as the wetness test shows), is described as the timber of **Lagerstrœmia-Flos-reginæ**, or *Pyinma*. The colour of this wood is brown or light walnut.

A block, weighing 599·3 grams, was tested for density. The specific gravity was 0·669 and the heaviness 41·77℔ per cubic foot.

Some shavings dried in an oven at about 180°F. for eleven hours showed the amount of moisture in the timber to be 13·77 per cent. reckoned on the weight of the dry wood.

Shearing Test.—Two tests were made: (*a*) with the shearing plane about parallel to the annual rings, (*b*) with the shearing plane about at right angles to the annual rings.

(*a*) Block 69c.

Dimensions, 1·935 × 2·036 inches.
Area sheared, 3·939 sq. inches.
Shearing load, 3,588lb.
Shearing stress 910·8lb per sq. inch = 0·407 tons per sq. inch.

(*b*) Block 69d.

Dimensions, 1·985 × 1·980 inches.
Area sheared, 3·930 sq. inches.
Shearing load, 2,349lb.
Shearing stress, 597·7lb per sq. inch = 0·267 tons per sq. inch.
Mean shearing resistance, 754lb, or 0·337 ton per sq. inch.

Transverse Test.—Two tests were made with rectangular bars on a span of 45 inches—

Bar 69a.—Width, 3·503 inches. Depth, 2·592 ,,
Bar 69b.—Width, 3·629 inches. Depth, 2·607 ,,

Load at Centre, in pounds.	Deflections, in inches.		Load at Centre, in pounds.	Deflections, in inches.	
	69a.	69b.		69a.	69b.
0	...	...	2,000	0·569	0·677
250	0·085	0·106	2,250	...	0·736
500	0·170	0·212	2,500	0·927	0·787
750	...	0·286	3,000	...	1·036
1,000	0·362	0·368	3,500	...	1·256
1,250	...	0·451	3,960	Broke.	...
1,500	0·520	0·526	4,000	...	1·466
1,750	...	0·572	4,398	...	Broke.

Both bars broke by tension.

The following are the results reduced :—

Bar.	Co-efficient of transverse strength.		Range of stress, in pounds.	Co-efficient of Elasticity.	
	Pounds.	Tons.		Lb. per sq. in.	Tons per sq. in.
69a	11,355	5·07	0 to 2,000	1,312,500	585·8
69b	12,037	5·37	0 to 2,500	1,125,400	502·4
Mean	11,696	5·22	...	1,218,950	544·1

Compression Test.—Two tests were made :—

Block 69e.—Dimensions, 2·452 × 2·499 inches.
Height, 6·55 inches.
Area crushed, 6·128 sq. inches.
Crushing load, 16·91 tons.
Crushing stress, 2·759 tons per sq. inch.

Block 69f.—Dimensions, 2·418 × 2·490 inches.
Height, 6·50 inches.
Area crushed, 6·020 sq. inches.
Crushing load, 16·68 tons.
Crushing stress, 2·765 tons per sq. inch.

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Both specimens broke fairly by shearing. The mean crushing resistance is 2·762 tons per sq. inch.

Considering that the wood is not very heavy, its strength is good.

Domestic and Sacred Uses.—Leaves used as manure which is very much appreciated (*South Kanara Report*).

Trade.—There appears to be no trade in this timber in any of the provinces of India, except Assam. The Forest Officers of the latter province write as follows:—"All timber removed is exported to Bengal. The price of a standing tree is R6." (*Garo Hills*). "Trade exists, about 20,000 cubic feet in logs being yearly exported to various places in the Sylhet District. Selling price varies from R1 to R2 per cubic foot" (*Cachar*); "from this district no export due to distance from large markets of Bengal and consequent heavy cost of carriage. The timber is used to a small extent locally, but there is no regular trade. Planks of this timber 15′ × 1″ × 18″ sell for R1-4 to R1-8 each" (*Lakhimpur*); there is little or no export trade—except perhaps in the form of boats (dug-outs) which are used on the Brahmaputra" (*Sibsagar*).

Supply.—The Forest Officers of Assam report that the outturn cannot even be approximately estimated owing to the trees growing scattered over large areas. That no great quantities can be supplied is due to the fact that there is a considerable local demand for it. All mature timber found in accessible places is greedily acquired by the natives. But there is no doubt that large stores in inaccessible places, when the country is more opened out, will be readily obtained.

The Forest Officer of South Kanara writes as follows:—"Limited as the tree is to narrow belts on river banks and its absence in any large numbers on such situations, the supply is here very limited."

The Forest Officer of Prome, Burma, states that "if a demand arose probably 200 or 300 tons could be supplied at R18 to R20 per ton in the rough."

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G. I. C. P. O.—No. 250 R. & A.—30-8-97,—2,200.—W. B. G.

(Industrial Series No. 1.)

THE

AGRICULTURAL LEDGER.

1897—No. 10.

HORNS, ANTLERS, AND HORN-WORK.

(BISON HORN.)

[*Dictionary of Economic Products, Vol. IV.,* **H. 408.**]

ORNAMENTAL WORK IN BISON HORN.

By E. H. AITKEN, ESQ., *Collector of Salt Revenue, Bombay. With introductory note by* MR. D. HOOPER, *Curator, Economic and Art Section, Indian Museum.*

Indian horn-work.

The subject of artistic horn manufactures in India has received very little notice in the hand-books and magazines on Indian Art. The contribution by Mr. E. H. Aitken, which constitutes the feature of this issue of the *Ledger*, is, therefore, specially valuable, as it records actual observations made in this peculiar industry in the western portion of India.

The horns that are usually employed in this country are those of the buffalo and the bison, as the gelatinous coverings present a suitable thickness and wide surface for the purposes required, and they can easily be removed from the bony skeleton.

Bengal horn-work.

In Bengal, buffalo horn ornaments are made at Monghyr and mainly consist of necklaces, bracelets, earrings and brooches. Combs and tooth-combs are manufactured in the city of Dacca where in 1882 there were said to be 20 to 25 establishments employing about one hundred Muhammadans whose knowledge of the fabrication of horn is hereditary.

The horns are procured from villages in the interior of the district, and before being shaped, they are softened by the heat of a furnace. The tools employed are with a few exceptions similar to those used by carpenters. The trade was at one time so prosperous that large

sales were effected in the neighbouring districts of Tipperah, Mymensingh, Mukhali and Sylhet. Horn walking-sticks are made by the Rarhi caste in Barabati, a town in the Balasor District of Orissa.

Madras horn-work.

In Madras, black horn is procured from the hill tracts of Vizagapatam District, and worked up by the Kamalis or Vishna Brahmins, a caste of men who are also employed in the ivory and inlaid sandal wood industry. Bézique boxes, blotting book covers, book slides and paper weights made of bison horn in Vizagapatam, and glove boxes, work boxes and card cases and picture frames of other kinds of horn were exhibited at the Melbourne Exhibition. All these articles were said to be very much admired and obtained a first class award.

Rajputana horn-work.

In Kotah, one of the Rajputana States, some very handsome articles are made of buffalo horn. These consist of powder flasks (*kuppi*), powder-horn (*singara*), and pen-boxes (*kalamdán*). The horn is first moulded by heating, cut to the required shape, and then inlaid with ivory and mother-of-pearl.

Horn buttons.

The extremities of the horns of most animals are converted into buttons by turning in a lathe, or the refuse pieces, when solid enough, are softened by heat and pressed into the form of buttons, and finished off by carving with a sharp knife. The turnings and shavings of horns are utilised by the chemical manufacturers in the preparation of prussiate of potassium.

Bombay horn-work.

The horn work in the Bombay Presidency is sufficiently dealt with in the accompanying note, but special attention should be drawn to the particular method of softening the horn practised in the Ratnagiri District. The method adopted in England, already referred to in the *Dictionary of Economic Products*, is to soften the horn by immersing it first in plain water, and afterwards in an acid bath for about two weeks. Other operators employ hot water, while in Dacca

Softening horn.

the dry heat of a furnace renders the horn malleable. The use of heated cocoa-nut oil referred to by Mr. Aitken must commend itself to everybody as the best process. The heated oil is not calculated to char or discolour the horn, a small portion would be absorbed and help to permanently consolidate the fibrous structure of which it is composed. Moreover, it gives a translucency to the finished article which is not observed in the horn work of other localities.

A practical observation of this kind is of great value, and may be far-reaching in its usefulness.

Ornamental Work in Bison Horn by **E. H. Aitken, Esq.,** Collector of Salt Revenue, Bombay.

Bison horn-work of Ratnágiri.

The art of making ornamental articles in bison horn is carried on by a very small number of men, who are also carpenters and metal workers, in the Ratnágiri district, especially at Viziadrúg. It does not appear to be an ancient art: they state that it has existed for only four or five generations, and has been handed down from father to son in the few families which practise it.

Articles made.

The reason given for working in bison horn is that the articles for which there is most demand are small stands for offerings, and other things which are used by Brahmins, and if they were made of cow horn the Brahmins would have nothing to do with them. The horns are mostly procured from Malabar, and cost as much as R1-8 or R2 for a single horn.

Natural sand-paper.

The process of manufacture is as follows: A portion of horn is kept moist with cocoanut-oil and heated before a fire until it becomes almost as soft as wax. This may take an hour or more. It is then worked, or pressed, into the required form, either with the hands or by means of moulds made of hard wood, and finished off with scraping tools and a small lathe. It remains to polish the whole and ornament parts of it with simple but graceful designs. The polishing is done with the leaves of a tree which grows in the district (**Ficus gibbosa,** *var.* **parasitica**), which are kept in stock in a dry state and moistened with water for use. The ornamentation is done in line with a fine, double-pointed, steel graving tool. The tools used in this work are indeed all extremely simple, and there are not many of them. A small, rude lathe, a fine saw, a few triangular blades, without handles, for scraping and polishing, a pair of compasses or callipers, three or four graving tools of sizes, with perhaps a file or rasp, and moulds made for the occasion, complete the necessary equipment.

Conf. Fig. 2.

It does not appear that the men work from any models or designs. Most of the figures are traditional. Perhaps the commonest article made is a *nandi,* or sacred bull, supporting a flat tray about seven inches in diameter, with a cobra rising out of the middle of it and rearing over it with expanded hood. The bull is in one piece,

HORNS. | **Ornamental Work in Bison Horn.**

Description of ornaments.

made from the solid half of the horn, which is always black. A hole is drilled in the back of the bull, in which is fixed the pedestal of the tray. This is another piece, and consists of a simple stem of solid horn, turned on the lathe. The tray is made from the base of the horn and is almost transparent. This is always made in a mould, after the horn has been thoroughly softened, and a good deal of labour is expended on it, the edges being scolloped and the border elaborately ornamented. But alas! it is fastened to the stem with a common screw nail. The cobra is also made from the translucent section of the horn and must be moulded into shape with the hands. It is fixed so that the head rears over the middle of the tray, while the tail, passing through a hole in the bottom, twines round the stem. The eyes and mouth of the cobra and the scales on its back are most minutely worked out. It will be observed that this is all line engraving. There is scarcely anything that can be called carving in the whole work. Moulding and scratching are the only processes to which the material lends itself.

Conf. Fig. 1.

Conf. Fig. 3

Other articles commonly made are small ornamental cups, covers for teacups, buttons and beautifully translucent, round boxes or caskets* for holding tooth-powder or other toilet requisites. Some of the best workmen, however, design and make much more ambitious works than these. A candelabrum, or lampstand, of most artistic design and elaborate workmanship, was lately sold in Bombay for R200. But even original and complicated pieces of work like this appear to be carried through without any model or design. The idea is in the workman's head, and the details grow under his hand. The figures employed in ornamentation are of a kind familiar to us in brass work and embroidery, and even rustic mural decoration, consisting of circles with regular or undulating circumferences, radiating lines, loops and rings, arranged in graceful, conventional patterns. As has been said, the principal purchasers of this ware are Brahmins, but the finer pieces of work are hawked about among Europeans, or wealthy natives, until a purchaser is found.

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* Similar boxes are also used as caskets for holding idols.—See *infra*.

Additional notes.

The following brief note is taken from the Descriptive Catalogue of contributions from the Bombay Presidency to the Calcutta International Exhibition, 1883-84, by Mr. John Griffiths and Mr. B. A. Gupte :—

"Viziadrúg, Jaitápur, and Málvan, in the Ratnágiri district, contain a few Sutár families, who know the secret of shaping bison's horns into cups, plates, animals, and caskets. About thirty years ago the only articles turned out were trays and caskets for the worship of idols, but of late cups of various shapes, lamp-shades, animals, notably snakes, are made to order for Europeans, which has given a start to the industry."

Ratnágiri horn-work.

The *Bombay Gazetteer*, Vol. X., published in 1880, thus describes the industry which is carried on in Ratnágiri and the neighbouring State Sáwantwári.

Ratnágiri : "Fancy articles of bison's horn are made by a few carpenter families with considerable skill at Viziadrúg, Málvan, and Rájápur. The industry is said to have been started some 200 years ago at Viziadrúg. The horn is imported in small quantities from Malabar and Cochin, the price varying from R1 to R2, according to size. The horn is heated on a moderate fire, and to make it malleable is softened with cocoanut-oil and wax. The articles, varying in price from R5 to R8, are card trays, inkstands, snuff-boxes, cups for idols, decorated with bulls, deer, and cobras, combs, chains, handles for sticks, and different kinds of birds and animals. The demand for the work, perhaps the only specialty in the district, is very limited, and the workers are few and much indebted."

Sáwantwári horn-work.

Sáwantwári : "Horn work is prepared by a few Hindu carpenters. Formerly horns were used only for dropping water over idols and for keeping gunpowder. Improvements were made about thirty years ago, and from thirty to thirty-five different articles are now offered for sale. The horns are partly found in Wári and partly brought from Malabár. Their price varies from As. 8 to R2. The left horn is more useful than the right as a water-horn in religious ceremonies, and fetches a higher price. The demand for the articles is less than it was ten years ago. The chief of these articles are: Polished horns, R1-8 to R10 each; lotuses, *kamals*, R3 to R15; caskets for keeping idols, *sampushto*, R2 to R7; other caskets, R1 to R5; cups, R1 to R5 a pair; trays from R2 to R7 each; small boxes from R10 to R30; handles for walking sticks, As. 8 to R7; small lamps, *nirúnjans*, R1 to R6 a pair; stools, R4 to R12 each; writing boxes, R15 to R50; knife handles, As. 2 to R1; wrist chains, R5 to R15 a pair; neck chains, R15 to R30 each; watch chains, R4 to R20; combs, As. 8 to R2; spoons, As. 4 to R1; tumblers R1 to R5; buttons As. 1 to As. 8; flowerstands, R5 to R20; antelopes, goats, cows, oxen, and buffaloes, R6 to R30 a pair; and elephants from R10 to R30 a pair."

Fig. 1.

Casket for holding idol (*Sampuhst*). From Viziadrúg, Ratnágiri, Bombay Presidency. Economic and Art Section, Indian Museum. Reg. No. 5240. (*About three-tenths natural size.*)

Fig. 2.

Kamal used as seat of Mahádeo. From Viziadrúg, Ratnágiri, Bombay. Economic and Art Section, Indian Museum. Reg. No. 5232. (*About one-half natural size.*)

Fig. 3.

Candelabrum. From Viziadrúg, Ratnágiri, Bombay. Economic and Art Section, Indian Museum. Reg. No. 5231. (*About two-fifths natural size.*)

(Entomological Series, No. 6.)

(Sericulture.)

THE AGRICULTURAL LEDGER.

1897—No. 11.

SILK.

(BURMA SILK.)

[*Dictionary of Economic Products, Vol. VI., Pt. III.*, S. 1829.]

THE SILK INDUSTRY IN YAMETHIN DISTRICT.

PYINMANA SUB-DIVISION.

Note by A. G. COOKE, Esq., I.C.S., *Sub-Divisional Officer, Pyinmana.*

The particulars given below are reproduced, with the permission of the Burma Government, as a supplement to *The Agricultural Ledger*, No. 26 of 1896:—

The villages at which silk is worked in the sub-division are the following:—

Chaungzu. | Swèdawmyaung.
Thayetchaung. | Pedônmyaung.
Myogôn.

The worm is said to have come originally from Kanyinmaw in the Magwè district. Hatching takes ten days; the caterpillars moult on the 5th, 8th, 12th, and 17th days after hatching, lying dormant for one day each time: ten days after the last moult they spin the cocoon. The fly which kills them when young is called *yingyi* here. The *sagaw*, the *paing*, *phine*, etc., are exactly the same as those described by Mr. Allan. The *sagaw* is kept covered for 22 days out of the 27. The cocoon spinning in the *paing* takes 24 hours; when it is complete they are put back into the *sagaw* for two days.

With reference to the *Po-win-oo* described and illustrated in Mr. Allan's note, on this side the Yoma C is the *pozet* (not *posit*), A and B being called *pozetlan*, there is an upright post or lathe to support the erection called *hmandaing*.

S. 1829.

SILK.

The Silk Industry in Yamethin District.

Ten *sagaws* are said to yield a viss * of silk. A viss of silk sells at about R12; the market is chiefly at Taungdwingyi. I cannot find there is any trade with Swa (Toungoo), and I do not think it probable as there is said to be a superior kind of worm used there. The process of working the *tanyinlôn* is called *nginthi*; from the *tanyinlôn* the silk is re-wound on to a larger instrument called *poyahat*, which resembles a cross thus—

and is turned by a wheel; this process is called *thuthi*. No weaving or dyeing is done here.

With regard to breeding, the bins, which are here called *gwe*, are placed on a cloth and about 20 females in one *gwe*; ten *gwes* are sold for the rupee.

The industry would be on a larger scale if the villages were not entirely surrounded by forest reserves, which limit the cultivation of mulberry.

* 1 *viss* = 3·65lb avoirdupois.

S. 1829.

G. I. C. P. O.—No. 331 R. & A.—30-9-97—2,200—G. R.

(Agricultural Series, No. 22.)

THE

AGRICULTURAL LEDGER.

1897—No. 12.

EMBANKMENTS.

(GRASS SOWING.)

[*Dictionary of Economic Products, Vol. III.*, E. 198 a.]

GRASS-SOWING OPERATIONS IN THE UMBALLA DISTRICT.

Extract from Correspondence between the Director of Land Records and Agriculture, Panjab, and the Senior Secretary to the Financial Commissioner, Panjab.

The information which follows is given as a supplement to *The Agricultural Ledger*, No. 21 of 1896:—

Extract, paragraph 4, of letter No. 1213, dated 8th June 1897, from the Director, Land Records and Agriculture, Panjab, to the Senior Secretary to the Financial Commissioner, Panjab.

*   *   *   *   *   *

4. As regards (2) planting and grass-growing operations begun by Mr. Gladstone in Umballa to fix sandy soils and improve pasture, the matter was last noticed in the departmental report for 1892-93, and Mr. Francis and Mr. Duthie's reports on the results of the experiments up to June 1893 were published in No. 21 of *The Agricultural Ledger* for 1896. The beneficial results of the movement started by him, not only in binding the soil by preventing the spread of sand and preserving the land at the foot of the Siwaliks from crumbling away into fissures, but also in developing the growth of the *bind pula** which found a ready sale as a thatching grass, are undoubted.

The impulse in the beginning depended entirely on Mr. Gladstone's personal influence, and has become weaker since he left the district, but where the people have begun to realise that it was

[* Saccharum ciliare, *and.* (S. Sara, *Roxb.*)

not merely a fad of the *Hakim*, but a source of direct profit, it has spread of itself. Captain Parsons informed me that in some villages in the Rupar Sub-division, the zemindars now cultivate the *bind pula* for sale, and that the town of Shazadpur Magra has been saved from erosion in the same way as Sadhaura (see *The Agricultural Ledger*, No. 21 of 1896, page 5) by a series of *bands* and plantations of *munj* grass which caught the silt at each flood and raised the level of the ground, thus finally causing a successful diversion of the stream. Captain Parsons is of opinion that a great many of the fissures which are so destructive in Umballa could be stopped if checked by *bind pula* at the first sign of their appearing, but he adds his conviction that this is working at the wrong end, and that defence against the ravages of *chos* and torrents should commence near their sources in the hills rather than in the plains.

E. 198 a.

G. I. C. P. O—No. 334 R. & A.—30-9-97.—2,200.—G R.

(Mineral and Metallic Series, No. 10.)

THE

AGRICULTURAL LEDGER.

1897—No. 13.

REH.

[*Dictionary of Economic Products, Vol. VI., Pt. I., pp. 400-426,* R. 67-70.]

RECLAMATION OF REH OR USAR LAND.

Second Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India, on certain experiments which have been carried out for that purpose.*

In *The Agricultural Ledger No. 5 of 1897* (1) the area and the nature of the *Usar* lands of the North-Western Provinces has been explained ; (2) the opinions of the several earlier observers has been quoted regarding the origin of the salts, and the means by which they have become accumulated in the surface soil ; (3) the experiments which have been made with a view to render these lands culturable, and the results obtained, have been detailed.

1. ***Object of present Note.***—In the present Note the results of many analyses which the writer has made of *Usar* soils, from different parts of India, are discussed, and from these information is given regarding the nature and quantity of the salts present in the soils at various depths from the surface.

In the next place are given the results of experiments carried out by the writer on the germination and growth of plants in artificial *Usar* soils, containing known amounts of certain salts.

Lastly, the effects produced on *Usar* soils by the addition of such salts as gypsum, which have the power of neutralising Sodium Carbonate, are dealt with.

2. ***The Amount of Salts in Usar Soils.***—It is hardly necessary to point to the importance of determining both the nature and the quantity of the soluble salts in these *Usar* soils. Without a clear knowledge of these two items the subject cannot be understood.

It will be well to quote, in the first place, the analyses of the samples which have been made by others, for the papers containing the latter are not generally obtainable and they should be put on record.

REH.

Reclamation of Reh

In Mr. Medlicott's Note, published in the Reh Committee's Report, are the following :—

Reh—Estimates in Soils.

		Soluble salts, parts in 1,000.
	Akrabad (Aligarh), field No. 93 :—	
A	1. Three inches cube of soil, including a thick crust of *reh*	18·80
A	2. Earth 2 feet below surface from a freshly dug hole within 6 feet of No. 1, surrounded by the same surface *reh*	2·44
A	3. Earth 6 feet from surface in the same hole . .	1·56
	Hydernagar, a hamlet of Nanon (Aligarh), field No. 769 :—	
B	6. Six inches square by 2 feet from a small (6 feet square) bare spot, but without efflorescence, in midst of a rich crop, on same level, and equally irrigated from a well; water 6 feet from surface, not saline to the taste	3·88
B	7. A like sample from close by, under rich crop . .	·45
	Dasnah, the field of Mr. Michel's experiment :—	
C	8. Three inches cube of soil, no visible *reh* . . .	1·13
C	9. Kankary earth 4 feet from surface . . .	1·74
C	11. Clay film (papery) from a dry channel close by .	4·07
	Sent by Captain Harrison, R.E. :—	
D	12. Shahpur (Cawnpur) field No. 199, "surface of *Usar* land in which an experiment in sub-soil drainage is being made"	2·73
D	13. Earth at 2 feet from surface	1·29
D	14. Earth at 5 feet from surface	1·51
	Gurioli (Farukhabad), field No. 322 :—	
E	16. Surface	9·20
E	17. Earth 2 feet from surface	2·73
E	18. Earth 5 feet from surface	0·80
	Quoted from *Journal, Royal Asiatic Society, London*, Vol. XX., page 336, 1863 : or *Sel. Govt. India, P. W. D.*, 42, page 43 :—	
F	20. Four inches cube of soil	4·00
F	21. Sub-soil just over water	2·00

Mr. Ward, of the Royal School of Mines, London, analysed the following samples of *Usar* soils from the neighbourhood of the Western Jumna Canal :—

Depth of sample of soil.	No. 1, 40 feet from Canal. Per cent. of total soluble salts in soil.	No. 2, 5,000 feet from Canal. Per cent. of total soluble salts in soil.
Surface	·2408	*3·0873
Two feet below surface . . .	·1535	·3611
Four feet below surface . . .	·0605	·4919
Six feet below surface . . .	·0984	·6934

* This residue included—

Sodium Carbonate	·9038
Sodium Sulphate	1·0929
Sodium Chloride	1·1419

R. 67-70.

3. Before detailing the analyses of *usar* soils which I have made, a few words may be said regarding the methods of sampling and the analysis.

For the selection of samples I adhered to one method. A hole having been dug, the samples of soil were cut from the side of the hole between certain depths. Thus, for example, a sample taken between 1″ - 6″ will represent the average state of the soil from the surface to a depth of 6 inches below it; one taken at 6″-2′ 6″ would be the average of the 2 feet of earth situated below the former. The soil having been "air-dried," it was shaken up with distilled water for a short time and then the whole thrown on a filter. In the earlier analyses it was attempted to allow the soil to settle, leaving a clear extract which could be boiled down; but this method is quite impracticable with the majority of the *usar* soils. One property of most *usar* soils, to which reference will be made more fully in another paragraph, is that they will not settle in water perfectly; even if allowed to stand for weeks together. The method of trying to obtain an extract of the salts by allowing the soils to settle was, therefore, soon given up and the extract obtained by filtration. The quantity of soil employed was in all, excepting the early cases, 100 grammes, which was digested in 500 c. c. of cold distilled water, and then the whole, including all the sand, thrown on to a perforated porcelain filter with a cloth covering. The first portions passing through are always muddy, but the *earth* sooner or later forms a perfect filter bed and the extract comes through clear. The muddy portion (which has already come through) is then poured back on the filter. By this means a clear extract is *generally*, though not always, obtained. It frequently happens, however, that the extract takes days to pass through, sometimes the whole will not pass through the filter at all, and also not infrequently a filtrate is obtained which appears only semi-transparent. Such extracts contain solid particles, which can be distinguished under the microscope, but they pass through the finest filters. The analysis of the extract is then carried out by the usual methods.

The figures in the statements are in all cases parts of salts per 100 parts of soil.

In calculating the results, all the chlorine is first considered as combined with sodium and then the sulphuric acid, so far as there is sodium for it to combine with. If any sodium then remains it is considered as carbonate. This assumption is based on the fact that Sodium Carbonate cannot exist in the presence of Magnesium or Calcium Sulphates or Chlorides. If these salts are brought in contact with solution of Sodium Carbonate, the latter is rapidly changed to Sulphate or Chloride as the case may be.

NORTH-WESTERN PROVINCES USAR.

4. The following are the examples of *Usar* soils which I have examined in the *Usar* plains of the North-Western Provinces and Oudh :—

REH.

Reclamation of Reh

(1) Samples were taken in a *Reh*-covered plain near Bilhaur, Cawnpur District—

	Village Alipur near Bilhaur.			
	26/93 Soil on surface, 1″ only.	27/93 Surface soil, 1″ - 13″.	28/93 13″ - 25″.	29/93 Salt from surface.
Na_2Co_3 . . .	2·910	1·081	·236	9·67
TOTAL SALTS .	2 909	1·152	·250	9·73

(2) A piece of land near the village Kakwan, Cawnpur District. The spot selected was occupied, on the one hand, by a rice field, in which hole "A." was dug, whilst the second hole "B." was made in a piece of grass-land (village-waste) close by. A *bund* separated the two. The rice field was without any visible sign of the presence of salt, whilst the grass-land was covered with it. The soil was in both cases the same, namely, a clay. Moisture was found at a depth of 6 inches in both holes. In both holes the plant-roots were observed to reach below the bottom, that is, to a greater depth than 40 inches—

	Hole "A."			Hole "B."		
	1″ - 6″.	6″ - 18″.	18″ - 30″.	1″ - 6″.	6″ - 18″.	18″ - 30″.
Total Salt .	0·009	0·017	0·017	1·198	0·293	0·520
Sodium Carbonate .	0·009	0·011	0·013	1·064	0·261	0·491
Sodium Sulphate .	...	...	...	0·013	0·029	...
Sodium Chloride .	...	...	...	0·042	0·009	...

(3) At village Ibrahimpur, District Cawnpur, two holes were dug 16 feet apart. Hole A. was in *Usar*; no sign of grass roots were left; it was moist up to the surface and very damp at 3 feet; *kankar* was met with at 4 feet 6 inches.

Hole B. was in soil on which grass was growing; no salt was visible; plenty of roots were found down to 4 feet, *kankar* was situated at 3 feet. The soil was equally moist with hole A. :—

	Reh patch. Hole A.			Grass patch. Hole B.		
	1″ - 6″.	6″ - 2′ 6″.	2′ 6″ - 4′ 6″.	1″ - 6″.	6″ - 2′ 6″.	2′ 6″ - 4′ 6″.
Sodium Carbonate	1·728	·254	·098	·402	·387	·327
Sodium Sulphate .	·264	...	...	...	...	...
Sodium Chloride .	·046	...	...	...	...	...
TOTAL SALTS .	2·012	·292	·c96	·428	·418	·395

(4) Near village Barauli, in District Farrukabad, I selected samples from a place where several patches of cultivation occurred in an *usar* plain.

Hole "A." was dug in a cultivated patch where the crop was good.

Hole "B." was made where the salts were efflorescing in large amount. It was 46 yards from "A." From it two samples were taken. Hole "C." was made where grass was growing well; it was 28 yards from "B." Hole "D." was dug where the grass was

covered with salt. It was 31 yards from "C." All the holes were in a nearly straight line.

	Hole "A."	"B."		"C."	"D."	
	1″ - 18″.	1″ - 6″.	6″ - 30″.	1″ - 30″.	1″ - 6″.	6″ - 30″.
Total Salt . .	0·012	1·494	1·616	0·016	1·415	0·209
Sodium Carbonate .		0 087	0·159		0·140	0·022
Sodium Sulphate .		1·318	1·388		1·186	0·191
Sodium Chloride .		0·116	0·097		0·087	0·020

Kankar was found in hole "B." at 4 feet from the surface and in hole "C." at 3 feet, but none was found in the other holes within the depth to which they were dug. It will be observed that the principal salt in this place was Sodium Sulphate. The soil was a clay-loam.

(5) The next case was of a somewhat different type. The foregoing are examples of soil covered with salt, near to which there was cultivation. It often happens that the people apply the term *usar* to land on which no salt is visible and this is such an one. The land was situated near Rasulabad, District Cawnpur, and a healthy crop was growing in the middle of one of these *usar* plains. It occurred to me, therefore, to have a hole dug, the one end of which extended into the cropped land, the other into the *usar*. The hole was 3 yards long and 1 yard deep. On examination I could discern no difference in the soil at either end. The soil was sampled to a depth of 3 feet and the results of the analyses are as follows :—

	In fields.	In *usar*.
Sodium Carbonate . . .	0·099	0·277
Sodium Sulphate . . .	very little.	0·125
Sodium Chloride . . .	0·018	0·055

(6) The following shows the quantity of salt in some *usar* land at Barra, Cawnpur District :—

	1″-6″.	6″-4′ 6″.
Sodium Carbonate . . .	·884	·194
Sodium Sulphate . . .	·156	...
Sodium Chloride . . .	·052	·007

(7) Near Unao, a hole was dug in an "*Usar*" plain on which no salts were visible, and an average sample of the first 4 feet of earth taken :—

Sodium Carbonate	·095
Sodium Sulphate	·071
Sodium Chloride	·005

(8) At village Seora, District Unao, samples of soil were taken from an *usar* plain. There was some salt on the surface. The soil was a loam, and the sub-soil water was only about 4-6 feet beneath the surface.

	1″-6″.	6″-2′ 6″.
Sodium Carbonate . . .	·537	·203
Sodium Sulphate . . .	·108	·044
Sodium Chloride . . .	·020	·020

(9) An *Usar* plain near village Amramau, Unao District, soil clay, with some salt efflorescing and grass growing on most parts of it. The hole was dug 4 feet deep; the earth was moist, no *kankar* was met with. Sub-soil water at about 4 to 8 feet below surface:—

	1″-6″.	6″-2′ 0″.
Sodium Carbonate . . .	·079	·043
Sodium Sulphate . . .	·234	·949
Sodium Chloride . . .	·064	·185

(10) In an *Usar* plain, village Banthra, Lucknow District, were patches of cultivation, the remainder being mostly covered with grass and but little salt was visible. In the cultivation were patches of soil on which no crop was growing, this being a common characteristic of *Usar*. Two holes were dug: Hole A. in the *Usar* land; Hole B. in one of the bare patches in the middle of a crop The soil at Hole A. was a clay, very dry and hard, no *kankar* was met with. At Hole B. the soil was a clayey loam, moist and no *kankar* was met with:—

	Hole A.		Hole B.	
	1″-6″.	6″-2′ 0″	1″-6″.	6″-2′ 0″.
Sodium Carbonate .	·164	·121	·001	·042
Sodium Sulphate .	·032	·019	·011	·007
Sodium Chloride .	...	...	·004	·007

(11) At village Chinhat, Lucknow District, the *Usar* land is of a lighter colour than south of Lucknow. The cultivated land is quite light loam. The *usar* is clay, with but little salt on the surface, *kankar* generally lying on the surface—

	1″-6″.	6″-2′ 0″.
Sodium Carbonate . . .	·197	·119
Sodium Sulphate . . .	·046	·011
Sodium Chloride . . .	·048	·044

(12) On an *Usar* plain to the north of Bara Banki are patches of cultivation. Holes were dug, A. in the *Usar* which bore grass, B. in a field of *Arhar* (**Cajanus indicus**). The soil was similar in both cases, being a stiff clay. Salt was not visible at either place, nor was any *kankar* present. The soil at A. was perfectly dry and very hard, that at B. was damp and soft—

	Hole A.		Hole B.
	1″-6″.	6″-2′ 0″.	1″-6″.
Sodium Carbonate . .	·099	·127	·008
Sodium Sulphate . .	·023	...	...
Sodium Chloride . .	·008	·016	...

(13) At village Jarwal, Bahraich District, was a small area with salt on it. This was, however, not an *Usar* plain in the ordinary sense, being mostly under cultivation—

	1″-6″.
Sodium Carbonate	·012
Sodium Sulphate	·084
Sodium Chloride	·080

(14) Samples of soil from two holes in the *Usar* Experimental "Reserve" at Gursikran, Aligarh, and from one hole in the land adjoining the "Reserve" contained the following amounts of salts :—

	Plot 35 in "Reserve."			Plot 24 in "Reserve."			Land outside "Reserve."		
	1″-12″.	1-3ft.	3-6ft.	1″-12″.	1-3ft.	3-6ft.	1″-12″.	1-3ft.	3-6ft.
Sodium Carbonate .	·172	·350	·271	·189	·089	·052	·588	·519	·243
Sodium Sulphate .	·073	·088	·055	·112	·042	...	·055	·042	...
Sodium Chloride .	·169	·187	·029	·385	·280	·058	·023	·023	·005

Grass was growing on Plots 24 and 35, but none where the other hole was made.

(15) Samples of soil were taken in 1896 from four holes in the same "Reserve" at Gursikran, Aligarh. Some land was ploughed up in 1895 and wheat was sown in the cold weather of 1895-96. It was then found that on some parts the wheat was most luxuriant, whilst on other places not a blade of corn grew. Two of the holes, Nos. 1 and 2, were in one plot of wheat, Nos. 3 and 4 were in another plot. In each case the pairs of holes were within a couple of feet of one another. Where holes 1 and 3 were made the wheat was excellent, whilst at the spots where holes 2 and 4 were made no wheat grew at all.

	Hole 1. Where Wheat grew well.	Hole 2. Where no Wheat grew.	Hole 3. Where Wheat grew well.	Hole 4. Where no Wheat grew.
1st Depth.	1″-6″.	1″-6″.	1″-6″.	1″-6″.
Sodium Carbonate .	·044	·193	·137	·251
Sodium Sulphate . .	...	...	...	...
Sodium Chloride . .	·021	·010	·062	·008
2nd Depth.	6″-1′ 6″.	6″-1′ 6″.	″6-1′ 6″.	6″-1′ 6″.
Sodium Carbonate	·061	·416	·043	·332
Sodium Sulphate . .	...	...	·013	...
Sodium Chloride . .	...	...	·005	·012
3rd Depth.	3′ 6″-4′ 6″.	3′ 6″-4′ 6″.	3′ 6″-4′ 6″.	3′ 6″-4′ 6″.
Sodium Carbonate .	·072	·240	·340	·237
Sodium Sulphate . .	...	...	...	...
Sodium Chloride . .	·017	·012	·023	...

REH. Reclamation of Reh

(16) Samples of soil from 6 holes in the *Usar* "Reserve" at Cherat. Aligarh, contained the following quantities of salts. Grass covered the land generally :—

	Hole 1.	Hole 2.	Hole 3.	Hole 4.	Hole 5.	Hole 6.
1st Depth.	1"-12".	1"-12".	1"-12".	1"-12".	1"-12".	1"-12".
Sodium Carbonate	·195	·647	·416	·813	·366	·325
Sodium Sulphate .	·013	·080	·038	·063	·172	·102
Sodium Chloride .	...	·095	·023	·071	·085	·012
2nd Depth.	1-3 ft.	1-3 ft.	1-3 ft.	1-3 ft.	1-3 ft.	1-3 ft.
Sodium Carbonate	·291	·585	·528	·881	·297	·431
Sodium Sulphate .	·024	·072	·023	·060	·094	·109
Sodium Chloride .	...	·102	·020	·092	·050	...
3rd Depth.	3-6 ft.	3-6 ft.	3-6 ft.	3-6 ft.	3-6 ft.	3-6 ft.
Sodium Carbonate	·105	·059	·115	·054	·022	·208
Sodium Sulphate .	·021	...	...	·029	·011	·013
Sodium Chloride .	·041	·008	·012	·153	...	...

5. Looking over the analyses of these various samples, it will be seen that generally the salt which is present in greatest quantity is Sodium Carbonate. In two cases only (Nos. 4 and 9) was Sodium Sulphate the principal salt; in four other cases it was present to the extent of ·1 to ·2 per cent.

In no case was Sodium Chloride present in considerable amount In the soil of Plots 24 and 35 at Gursikran this salt was present in amount varying from 1 to ·3 per cent.; but this is exceptional.

Also it will be seen that where the salts are present in any material quantity, the greater part is present in the first few inches of surface soil and the proportion then rapidly diminishes.

On the other hand, in those soils in which grass or other plants are growing, the salts are much more evenly diffused. This is very clearly seen in the case of the samples taken at Gursikran (Nos. 14 and 15) and Cherat (No. 16). In No. 15 at Gursikran (Holes 2 and 4) nothing was growing at the time the samples were taken, but grasses had been allowed to grow for many years until the year 1895.

PANJAB USAR.

6. In November 1895, I visited the Districts Karnal, Ferozepur, Muzaffargarh and the Chenab Canal in the Panjab, in all of which *Usar* land occurs. It is also called *kalrati* land, and the salts are called *kallar*. For the sake of uniformity the term *Usar* land will be adhered to.

With the exception of the *usar* at Muzaffargarh, which is low lying near the River Chenab, these Panjab tracts consist of very similar land to the *usar* of the North-Western Provinces and Oudh; they are level lands of yellow alluvium containing a high proportion of clay.

The following notes describe the *usar* of Ferozepur, the land in the neighbourhood of the Chenab Canal, and Muzaffargarh, the chemical analyses of the soils being added. In addition to these some analyses of *usar* soil from Lahore are given.

7. ***The Chenab Canal.***—I travelled over the following route on this canal: Killa Ram Kaur, Vaniki, Kolotara, Saidnagar, Sagar, Nanuana, Marh, Mochiwalla, Sangla.

Speaking generally there is a distinct difference between the land which I saw on this route from Killa Ram Kaur to Sagar and that which I examined between Sagar and Sangla.

In the former indicated country the village sites appear to be generally on a soil of good brown loam, well cultivated and bearing a fair number of trees. In between them there are large stretches of a greyish clay. These are the so-called *kalrati* lands. They are rarely cultivated and a few *babúls*, etc., are the only trees which break their monotony. The vegetation is scantier than on similar land in the North-Western Provinces, but they are rarely cut up by surface drainage (perhaps because the rainfall is lighter).

But, although these *kalrati* lands have been considered to be unculturable on account of the salt they contain, I found only very slight evidence of the presence of such injurious substances, indeed it was only here andthere in the water-courses that any indications of efflorescing salts were to be seen.

The following are the analyses of samples of soil taken at four places in uncultivated *kalrati* land; there is in addition one sample of *cultivated kalrati* land and one of a good loam near some *kalrati* land at village Kaliki.

(*a*) and (*b*) were taken in land in village Kolotara at a spot 200 yards north-north-west of the 29,000 feet stone on the Gajar Gola Rajbaha. No grass was growing and no salt was apparent on the surface, but some little salt was to be seen in the water-courses.

It was about the worst spot I could find in the neighbourhood. The analyses show that there was some amount of Sodium Sulphate, with much smaller proportions of Carbonate and Chloride. The land in the vicinity was being brought under cultivation. (*c*) and (*d*) were taken from two spots near the Sagar Bungalow in *kalrati* land, and they contain practically no salts at all. (*e*) was selected from the surface soil of a cultivated field of *kalrati* land near sample (*c*). (*f*) is a sample of good loam from a field near Sagar Bungalow (*g*) and (*h*) are from village Kaliki, 2 miles north-west of Nanuana Bungalow. This land is of the same nature as the foregoing, is a stiffish clay, and is termed *kalrati* by the people. There was no vestige of salt on the surface, and, as will be seen, the surface soil contained practically no harmful salts; whilst the sub-soil contained a little Sodium Sulphate. Nor was there in the vicinity any salt in the

water channels or on the spots where water must occasionally lodge after rain. Sample *(i)* was from a field of good loam from village Kaliki.

In the country south-east from the Nanuana Bungalow, in villages Burj Dara and Dinga, the cultivated lands appeared to be somewhat stiffer than at Kaliki, whilst the grazing areas seemed to be of a distinctly lighter nature than the *kalrati* clays. A little salt was present in one or two of the irrigating channels due possibly to the well water used; but it had not produced the bare patches in the fields which are so characteristic of the North-Western Provinces *Usar*—

	Kolotara.		Near Sagar Bungalow.				Village Kaliki.		
	200 yds. N.-N.-W. of 29,000 ft. stone on Gajar Gola Rajbaha.		600 yds. S.-E. from R. D. 119.	200 yds. S.-E. from R. D. 119.	600 yds. S.-E. from R. D. 119.	Good loam.	2 miles N.-W. of Nanuana Bungalow. *Kalrati* land.		Good loam.
	(a) 1″-6″.	*(b)* 6″-1′6″.	*(c)* 1″-6″.	*(d)* 1″-6″.	*(e)* 1″-6″.	*(f)* 1″-6″.	*(g)* 1″-6″.	*(h)* 6″-1′6″.	*(i)* 1″-6″.
Sodium Carbonate .	·045	·171	*Nil.*	*Nil.*	·041	*Nil.*	·007	·054	*Nil.*
Sodium Sulphate .	·801	·475	·034	*Nil.*	*Nil.*	*Nil.*	·076	·219	*Nil.*
Sodium Chloride .	·146	·040	·011	·011	*Nil.*	·005	·005	·017	·029

8. In a Note written by Mr. M. F. O'Dwyer, C.S., in 1894 the *kalrati* lands of this locality are thus described :—

"The villages in the 1st Division of the Chenab Canal irrigating from the Vaniki, Gajar Gola, and Kalianwala Rajbahas and the Kot Nikka branch, have, as a rule, a large part of their areas affected by *kallar*, otherwise known as *shor* or *reh*, when it takes the form of a white efflorescence on the surface. The soil in which these sodium salts are found in deposit is generally a stiff clay, sourish or salt to the taste, and is known as *kalrati* in contrast to the sweet clay known as *rohi* which is the best of all soils. The *kallar* or *kalrati* land sometimes rests on a stratum of *kankar*. Previous to the opening of the Chenab Canal no attempt was made to cultivate this sour clay except here and there in low hollows, where drainage water collected. It was too stiff and thirsty to grow *barani* crops with the small rainfall of this tract, and the zemindars were averse to sinking wells in it,

partly owing to the difficulty of boring through a stratum of hard clay, with perhaps layers of *kankar* sandwiched in here and there, but chiefly because they believed that the land could not be made productive even with well water, which, they said, would bring the *reh* or *shora* to the surface and render the land worthless. In fact in previous settlements this land, which in round numbers embraces over one-third of the total area of the Wazirabad Tahsil, and about one-fourth of Hafizabad, was recorded as *ghairmumkin, i.e.*, unculturable waste."

I had, therefore, expected to meet with a state of things similar to those in the North-Western Provinces and was somewhat surprised to find so little evidence of salts in the soil. The analyses leave no doubt, however, that, excepting here and there, this soil is not (at least at the surface) seriously impregnated with sodium salts. Like all this Indian alluvium, the sub-soil drainage is liable to be imperfect, more especially in the absence of vegetation, and probably on this account all these waste lands contain a small proportion of sodium salts. It cannot be too carefully borne in mind that, although this *reh* is in all probability the refuse sodium salts of the soil, liberated but not assimilated by plants, and although also, the amount of water withdrawn from below by plants in cultivated areas and dissipated into the atmosphere is greater than where vegetation is absent or but poor, there is at the same time in cultivated land a much more perfect *circulation* of water, the roots descending, as they do for many feet, keep the sub-soil open, and the natural conditions for drainage are fulfilled. These *kalrati* lands certainly appear in some cases to be quite different from the cultivated lands round the villages; they are generally clays, and it appeared to me that herein lies possibly the explanation why they are generally left for grazing; they are more difficult to plough and cultivate and the people will naturally choose the loams for raising produce so long as there is any choice in the matter. With the advent of a plentiful supply of water, such as is assured by the Chenab Canal, their cultivation of this land is rendered comparatively easy and, although there seems to have been at first a belief among the people that such land would not produce crops, that creed has now broken down and doubtless they will be cultivated in the future, a change which will probably be very beneficial to them. Touching this point I quote again from Mr. O'Dwyer's Note—

"As remarked by Fateh Ali Shah, Zilladar, in his report, even when the canal was opened in July 1887, the zemindars thought it useless to attempt breaking up this land even with canal water, and it was not till a few of the more enterprising set the example by growing rice with success on *kallar* land, that their opposition was overcome. Thereafter there was a general movement to growing rice on such lands with canal irrigation, which is still extending, and many villages with a light loamy soil far superior to the *kallar* for *barani* or well cultivation, now envy their neighbours the possession of the large *kallar* areas, which till the advent of the canal were regarded as worthless even for grazing."

"So slow, however, are the people to give up the old tradition, that even after they had seen good crops of rice grown on *kallar*, they

fell back on the opinion that such land would after one or two croppings become exhausted and afterwards become quite barren When I joined the Settlement in September 1889, this was the universal cry of the Hafizabad zemindars. When I now confront them with the fact that the same land has gone on yielding excellent crops of rice for six or seven years in succession, they have to give up that position, but fall back on another and at present more plausible one, *viz.*, that this *kallar* land will grow only rice, and that in yearly decreasing quantities, and will not grow spring crops such as wheat or barley."

"Meantime other *kallar* villages (there is an extensive group of them from Jalalpur to Pindi Bhattian running parallel with but beyond the influence of the river) which have not yet received any canal irrigation, are clamouring to have canal water extended to them, and complain that, unless this is done, they will be completely broken down, as tenants are deserting them for the more profitable and less laborious cultivation on the canal."

9. ***Nanuana to Marh.***—For several miles after leaving Nanuana, the soil on the south-eastern side of the canal is in many parts fairly clayey. Passing them to the other (north-western) side of the canal, I found that the soil becomes somewhat lighter in nature as one approaches Mochiwalla Bungalow, and there were occasional appearances of salt in the canal banks. But the land, even in the depressions or holes, did not exhibit any accumulations of salts, as is generally the case in *Usar* land. Here and there the surface had the thin black crust, which all the more clayey soils exhibit in the waste areas.

Near Mochiwalla and thence more or less all the way to Marh there are more indications of salts in the surface soil than I saw elsewhere on this canal. There is a fairly strong patch on the northwestern side of the canal at Mochiwalla, between it and the Rajbaha, but further out in the waste land the salts disappear again and the soil seems to be somewhat more clayey. In the following statement of analyses those marked (*a*) and (*b*) are from a hole close to the bridge in the area between the canal and the Rajbaha. Here there was a very considerable amount of salts in the soil, most of which was at the surface.

From Mochiwalla to Marh the soil appeared to become decidedly less clayey and a newly sown hedge of *shisham* near the canal was flourishing (excepting in places), and showed excellent growth for the eight months since it was planted. But here and there near the road little patches occur, where salts have effloresced on the irrigation channel of this hedge, and the trees have died away here in great measure. To the west of the Marh Bungalow the soil is everywhere a yellow loam and even sandy in places. Nevertheless there are in many of the fields very distinct signs of salt efflorescence exhibited in some places by the weak patches in the *rabi* crops, whereas in others the salts had effloresced on the surface. The analyses (*c*) and (*d*) are of soil taken from a level place (about 50 yards north-west of the

Railway and 100 yards north of the road to Marh), next to a field where a considerable bare patch had occurred in a turnip crop. The soil was a red loam. No salt was apparent on the surface. Here there was hardly any Sodium Carbonate; the greater part of the salts consisted of Sodium Sulphate.

Further to the west of the village Marh there is an area much more seriously affected and which has all the characteristics of the North-Western Provinces *Usar*. The salts had cropped out here badly in places and the soil was somewhat clayey.

For some miles the bank of the canal between Marh and Sangla has proved to be readily attacked by the water—the soil does not bind and the salts crop out badly everywhere on the banks. A new bank is being formed by allowing the canal to deposit silt in tanks on the north-western side of the canal. In the bottoms of those of the tanks to which water had not yet been admitted, the salts had effloresced.

Analyses *(e) (f)* and *(g)* in the following statement are those of soils taken from a spot south of Sangla Bungalow. It is fairly representative of the sort of land in that neighbourhood. Here again there was but little Sodium Carbonate, the greater part of the salts consisted of Sodium Sulphate—

	Mochiwalla Bungalow.		Half mile W. of Marh Bungalow.		Sangla Bungalow Compound.		
	(*a*) 1″-6″.	(*b*) 6″-1′6″.	(*c*) 1″-6″.	(*d*) 6″-1′6″.	(*e*) 1″-6″.	(*f*) 6″-1′6″.	(*g*) 3′6″-4′6″.
Sodium Carbonate .	2·175	·045	*Nil.*	·057	·120	·148	·035
Sodium Sulphate .	1·318	·185	·256	·557	1·312	·944	·277
Sodium Chloride .	·624	·093	·163	·280	·654	·572	·175

10. From the foregoing it will be evident that, judging by the state of the surface soil, the *kalrati* lands in the vicinity of the upper part of the Chenab Canal, there is very little salt at all. Even with half a per cent. of Sodium Sulphate it is doubtful, for reasons set forth in paragraph 32 of this paper, if it would occasion serious damage to crops. It is also probable that the more vigorously such land is cultivated, the more perfectly will these salts be prevented from accumulating at or near the surface, even if they do not entirely drain away.

Within the area further down the canal, *i.e.*, from Mochiwalla westwards, there seemed to be much more salt in the soil. At the same time it appears to be principally Sodium Sulphate with small proportions of Carbonate. The amount of Chloride appears to be larger than in the North-Western Provinces and Oudh soils.

11. ***Muzaffargarh Usar***.—In the Muzaffargarh District, there is much evidence of *Reh* in the *khadir* land of the Chenab River. This *Reh* bears the characteristic appearances of "black

alkali" as the Americans call Sodium Carbonate; it appears in both cultivated as in uncultivated land, and it was frequently a matter of surprise to me that crops grow in this land at all. The soil is, however, all river silt of recent origin and contains a high proportion of sand in the sub-soil. In some of the grazing grounds I found pure coarse sand thrown up by moles or worms. Moreover, the land is liable to occasional floods from the river Chenab, as occurred in 1894. Hence it is probable that the salts are caused to diffuse through the soil annually more or less and only concentrate at the surface for comparatively short periods of time. The sub-soil water level is everywhere near the surface, averaging 5-10 feet.

The following samples of soil were selected and analysed:—(*a*) To the west of Muzaffargarh there is a bad piece of *usar* which affects alike cultivated and uncultivated land, though, as usual, the salt appears in greater quantity on the latter.

Hole 1 in grazing land where water flows or lies late; no grass grew just here though the main portion was covered with a tall coarse grass. There was cultivation, with well irrigation, 100 yards off. Water at 10 feet from surface. The soil consisted of river silt with no clay, and moisture existed up to the surface.

Hole 2 in the same grazing ground, though half mile further north; the conditions were similar to those at Hole 1, but the salt seemed to be present in larger amount. Water probably lies here after the rains. The soil was somewhat drier than at Hole 1; moisture appeared at about 8 inches below the surface.

The analyses are set out in the following statement. At both places there was a large amount of both Sodium Carbonate and Sulphate; more than sufficient to damage crops.

(*b*) At a village Gazanfargarh, about 18 miles south of Muzaffargarh, there is a piece of bad *usar*, which is a regular swamp and appeared to extend a considerable distance. The samples from "Hole 3" in the statement were taken at a fairly bad place. The soil consisted of dark-coloured silt, not clay, with moisture up to the surface. This area is not cultivated, but used as a grazing land and appeared to be subject to periodical submersion by water. A part of it was occupied by a *jhil* at the time of my visit. A sample of average good cultivated land was taken at the village Mohammadpur, near Gazanfargarh, and the analysis is labelled Hole 4 in the statement.—

	Muzaffargarh, Hole 1.		Muzaffargarh, Hole 2.		Gazanfargarh, Hole 3.		Mohammadpur, Hole 4.
	1"-6".	6"-1'6"	1"-6".	6"-1'6".	1"-6".	6"-1'6".	1"-6".
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sodium Carbonate .	3·071	·197	·733	·337	1·043	·248	*Nil.*
Sodium Sulphate .	1·407	·115	·545	·502	1·583	·368	·088
Sodium Chloride .	·076	·035	·163	·046	1·255	·017	·052

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But all the way from Muzaffargarh to Gazanfargarh there is much *Reh* in the fields, and I was surprised to see so much cultivation. There were many cultivated fields which apparently had as much *reh* in the surface soil, as would have prevented their cultivation in the North-Western Provinces. This is, I believe, not due to any superiority in methods of cultivation or to the presence of an especially good class of cultivator. In fact the reverse was rather the case, the implements and cattle being of a worse class than in most parts of the North-Western Provinces, and the cultivation generally anything but good. Nor is the nature of the salts of a less pernicious description than in other affected places, for, as the analyses show, they consist of Sodium Carbonate and Sulphate in about equal amount. I believe that it is in a great measure due to the presence of a large proportion of coarse sand in the sub-soil and the consequent open nature of the land, together with a plentiful supply of sub-soil water near the surface, thus probably allowing the salts to become periodically diffused more or less, that the cultivation is as good as it is.

12. ***Ferozepur District.***—In this district I saw (during a journey from Ferozepur to Jellalabad) but little *usar* or *kallar* land. Near Ferozepur some of the land of one village was affected, and again at Jellalabad there was an area of *usar* land.

From the analyses of these soils (*vide* the following statement) it will be seen that the amount of salts present in the surface soil of the cultivated fields near Ferozepur was not inconsiderable, though there was at the same time no Sodium Carbonate. The land at Jellalabad contained very considerable quantities of all the three sodium salts:—

	Usar soil from cultivated field in village near Ferozepur.	*Usar* soil from uncultivated land at Jellalabad, Ferozepur District.	
	1″-6″.	1″-6″.	6″-1′6″.
Sodium Carbonate	*Nil.*	1·688	·142
Sodium Sulphate	·834	4·165	·520
Sodium Chloride	·204	1·400	·087

13. ***Changa Manga.***—Outside the Changa Manga Fuel Reserve the land is a bare grazing area, with but little scrub jungle, and the soil was dry and very hard at the time of my visit. The following analysis shows the amount of salts in the surface soil per cent.:—

Sodium Carbonate.	Sodium Sulphate.	Sodium Chloride.
Nil.	·017	·011

This land may be said to be practically free from Soda salts.

R. 67-70.

14. ***Lahore***.—There is some salt present in the surface soil of the Lahore Horticultural Gardens, and the following analyses of two samples of this land may be quoted. It will be seen that it consists principally of Sulphate and Chloride with minor quantities of Carbonate:—

	Sodium Carbonate.	Sodium Sulphate.	Sodium Chloride.
1 .	·043	1·059	1·364
2 .	·148	·277	·364

15. As regards these *usar* soils in the Panjab one may now draw one or two conclusions:—

First.—It will be seen that all along the Chenab Canal, and at Lahore, Ferozepur and Changa Manga, the principal salt present is usually Sodium Sulphate, though at Mochiwalla on the Chenab Canal, the major part of the salts was Sodium Carbonate. At the Lahore Gardens there was a good deal of Sodium Chloride.

In the *khadir* of the Chenab River in Muzaffargarh District there was a considerable amount of both Sodium, Carbonate and Sulphate.

Secondly.—It may be safely asserted that much of the land which is termed *kalrati* in the neighbourhood of the Chenab Canal does not contain much if any of these Sodium salts. It is a heavy clay soil, difficult to cultivate, and probably for this reason the people have raised their crops on the lighter loamy soils.

Thirdly.—As in the case of the North-Western Provinces *Usar*, the greater part of the salts exists in the surface soil.

USAR IN GUJARAT, BOMBAY.

16. In the Kaira District of Gujarat, Bombay, there is a small area of land which is affected by accumulations of salts in the surface soil, and the following gives a description of it. It is a peculiarly small well-defined area in a country which is otherwise free from *usar*, and is in this respect different from that found in the North-Western Provinces and Panjab.

I travelled with Mr. Ozanne from Dakor along the main road to Kapadvanj, and back, and visited a number of villages on each side of the road. Evidences of salty efflorescence are to be found in many of these villages, but with the exception of the tract, presently to be defined, the salty patches in the other villages are of no moment at all.

The main tract of land which is affected by this salty efflorescence, and which the people call *usar*, seemed to me to be very well defined. It commences a little to the north-east of Lasundra and runs westward towards the Mohar River.

As to the other villages which I visited, Chiklod, to the east of the main road, contains no *usar*, in Navagam, Jaloia and Thunchal to the north-west of Kapadvanj, I found small patches of salty efflorescence in one or two depressions which are tanks in the rains; in villages Mirampur, Ambliara, Wasna, Daiap, I found no *usar*. Between Daiap and Sikandra Porda there was a small area which was slightly affected. This was near a tank.

In the villages Laksmanpura (excepting the northernmost part), Samalpura, Chetasamba and Ajupura there was likewise no *usar*. The only area which was at all badly affected was that alluded to and includes Lasundra, Ladvel, Laksmanpura (northernmost part), and Kathana, and seems to be coincident with a drainage area which occupies the same ground.

17. Regarding the nature of the soil of this part of the Kaira District, it varies from a description of black soil to a light yellow one.

Although the junction of these soils is not in any one very distinct direction, it is nevertheless very well marked everywhere, the change being complete within a few yards.

At Chiklod the soil is black for the most part, and it is the same to the eastern side of Lasundra, whilst the villages Laksmanpura, Samalpura, Chetasamba, Ajupura are all on this black soil. On the other hand, the villages Kathana, Ladvel, Lasundra (west part), Daiap, Dana, Ambliara, Mirampura, are all on a light yellow soil. The same sort of soil lies to the north-west of Kapadvanj across the Mohar River.

Regarding the black soil of the district, it is in some respects quite different from the true "Black Cotton" soil, although it resembles it in others.

It has no loose surface soil, but is hard and impervious instead; it cracks like the "Black Cotton" soil, but the cracks are much smaller; in the grazing lands there are numbers of large holes 1 foot and 2 feet deep where the water has last lain. *Kankar* underlies it in many places.

The yellow soil is similar in colour and general character to that found in the North-Western Provinces. It is distinctly sandy for the most part, and I saw no large area which could be called clay, though here and there the soil of a field approaches to that character. *Kankar* underlies these soils also very generally.

As usual, the thickness of the *kankar* varies very much indeed; in some places it is only a few inches thick, in others it is many feet and in one place, Samalpura, it measured some 25 feet in thickness. But this is exceptional, and generally it was 1 or 2 feet in such holes as I came across or had specially dug.

18. The water level of this area varies very rapidly indeed. At Ladvel it was, at the time of my visit, 11 feet from the surface, at Chetasamba in some grazing land, it was only 2 feet, at Samalpura it was some 30 feet, whilst at Ajupura it was 60 feet from the surface.

19. Turning now to the samples of soil which I collected (*vide* Statement attached), the two from Lasundra were taken from holes about 40 feet apart in some land which was apparently affected by salts. Field No. 723 (original survey) was under cultivation; the rice of the last monsoon had been all right, but the gram (**Cicer arietinum**) crop was more or less a failure. It was then on the ground and the hole was dug where the crop had failed. The surface soil 1″-8″ was hard, dry and clayey; moisture met with at 1 foot and soil sandy loam from 1′-2′ 6″, then clay. Field No. 719 (original survey) was lying waste and was in a much worse condition

as regards salt efflorescence than No. 723. The top soil was sandy loam and clay was met with at 4 feet. Both these fields are close to the main road. It will be seen from the Statement that hardly any soluble Sodium or other salts was in the surface soil of field No. 723, whilst there was about two-tenths per cent. of Sodium Chloride and rather more Sodium Carbonate in the surface soil of field No. 719. The sample taken at village Chiklod was not *usar*. It was from a piece of grazing ground which the people said was very poor, but there was no outward sign of salt on the surface. There is, as the analysis shows, some Sodium Chloride, but nothing else worth mentioning. The other eight samples, three from Ladvel, one from Laksmanpura and four from Kathana, represent the state of the worst parts of the drainage channel. The three samples from Ladvel were from a hole in grazing land where no grass grew. It was apparently a good loam down to 2 feet where it became more clayey. The surface soil contains over half a per cent. of both Sodium Chloride and Sodium Carbonate, whilst there was very little Sodium Sulphate, but, as the second sample shows, the soil below 6 inches becomes rapidly purer, the proportion of Sodium Chloride amounts to only about one-tenth per cent., the Sodium Carbonate having decreased to less than four-tenths, whilst at 1 foot 6 inches deep the Sodium Carbonate is less than two-tenths per cent.

The sample from Laksmanpura contained over two per cent. of Sodium Chloride with very little else.

The chief feature of the soil in the two fields in village Kathana from which samples were taken, is the Sodium Chloride they contain, whilst the amounts of other salts is quite subordinate. As in the Ladvel soil, the major portion of the salt is in the surface soil.

20. Thus in the case of this land the predominating salt is Sodium Chloride accompanied by smaller amounts of Sodium Carbonate; Sodium Sulphate is present only in very small amount in the majority of the samples.

SALTY LAND IN THE DECCAN, BOMBAY.

21. In the neighbourhood of the Nira Canal there are certain areas which have become affected with salty accumulations. Under instructions from Government I examined this land in 1894, and the following extracts from my report give a description of the conditions under which the area was existing at the time of my visit. In the country contiguous to the Nira Canal I inspected six areas which were pointed out to me as having been injured by the canal.

22. There is a remarkable similarity between all the six cases.

It is striking as one passes along the road (parallel to the canal which runs from west to east) how the rotation of (1) hill almost bare of soil, (2) reddish soil with rock, near the surface, (3) black soil, deep in most places in the centre of the valley, recurs. In the same way the canal seems to pass (1) through hard rock, (2) through soft rock called "Murum," (3) over the black soil of the *nalla*. Such was what I observed as I passed from Baramati to Nira, and here are

or Usar Land. (J. W. Leather.) REH.

Analyses of Soils from the Kaira District, Gujarat.

	115.	116.	117.	131.	132.	133.	130.	126.	127.	128.	129.
	Lasundra.		Chiklod.	Ladvel.			Laks-man-pura.	Kathana. Rice land.		Kathana. In drainage area.	
	Field No. 723' Surface Soil.	Field No. 719' Surface Soil.	Field No. 282, Surface Soil.	Surface Soil. 1″-6″.	Sub-soil. 6″-1′ 6″.	Sub-soil. 1′ 6″-2′ 6″.	Surface Soil. 1′-6″.	Surface Soil. 1″-6″.	Sub-soil. 6″-1′ 6″	Surface Soil. 1″-6″.	Sub-soil. 6″-1′ 6″.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sodium Sulphate	...	·021	·029	·098	·039	·030	·206	·145	·033	·345	·114
Sodium Chloride	·005	·196	·187	·561	·133	·153	2·244	1·331	·377	1·350	·433
Sodium Carbonate	·005	·263	·c26	·562	·375	·183	·100	·083	·063	·118	·073

R. 67-70.

included the areas of villages Pandare, Wadgaon, Karanje and Nimbut. All the six areas examined are in the immediate vicinity of a *nalla*. The soil in each of the affected areas is almost entirely black. They are all on the "down stream" side of the canal, and in all the cases the greatest injury appears to commence at some little distance, 50-150 yards from the canal, from whence it extends. The areas are all very badly water-logged, and in all, salty patches occur here and there on the surface. Lastly, the erosive action of storm-water appeared to me to be serious. The Nira Canal commands a gross area of 300,000 acres, of which 107,000 acres are irrigable and it cannot be spared. It is necessary, therefore, to consider how the evil, which I understand Government admit is due to this canal, may best be contended with. Leaving out of account for the time being the source of the salt accumulations, the first question, "What is the cause of the water-logged condition," may be dismissed readily. I have said that I understand Government attribute this to the canal, and the evidence which I obtained from the Canal Supervisors, both of whom have resided in these districts for many years, coincides with this view. They both showed me the fields which they could remember as being fertile, and which are now barren.

The Supervisor of the Nira section of the canal seemed to me an exceptionally observant man, for he showed me how he used certain objects as land-marks by which he could roughly measure the rate at which the land had been going out of cultivation. Indeed no one going over these lands could well come to any other conclusion, and I certainly agree with it. The next question is, whether the leakages can be stopped either partially or entirely. It is, however, one rather for the Canal Department to deal with, and I shall not attempt to discuss it.

23. Then, as to the area which is affected, and also the question, "Is that area increasing?" On this point, I understand, there is no information, and to my mind it is quite as important as the one which I shall presently consider, namely, the means to be taken to overcome the difficulty. Nothing has helped me so much in making my observations as Mr. Ozanne's notes. With these he includes sketches of the fields which he visited, and I was thus enabled to compare their present state with that of 1889. It was by their aid that I could determine the fact that areas under the Mutha Canal, noticed in another part of the Report, which were in a bad condition in 1889, are now certainly not worse, and are probably better, than they were; and had I had similar information as to the state of the different fields near the Nira Canal, a definite conclusion might have been formed as to the progress of the evil. Baramati was, however, the only one of the areas on this canal visited by Mr. Ozanne and myself. Mr. Ozanne's notes do not include the exact position of the crop which he saw on the ground, but since I could find only two small plots of *juar*, besides the plantain grove in field No. 233, I think it may be safely stated that the evil has spread. It seems to me, therefore, that one of the first things which Government should take in hand is (1) the determination of the affected area, and (2) the determination

of the question whether the evil is spreading and at what rate. With regard to the first of these recommendations it is hardly for me to say how it should be done; for in the first place it will require careful discretion as to what fields have been thrown out of cultivation by the canal. I believe, however, that the Patel's books taken in conjunction with the position of the land in relation to the canal would afford a useful indication. The information can of course only be approximate.

24. Regarding the second suggestion, namely, the determination of the progress of the damage, I would recommend that certain specified areas should be chosen and the crops and other vegetation be actually recorded on the village maps, together with the condition of the uncropped area, whether swampy or not, the amount of erosion, etc., etc.

This work is not one which would absorb any extravagant amount of time. I may mention that in going over the fields at Baramati it occupied about three hours, and at Wadgaon, where I inspected eight fields and sketched the position of the crops in my note book, it occupied about one hour and a half. I do not consider that I did it very thoroughly: my time was limited; but the information gained in such a way as I have indicated would form an absolute record as to the state of the land.

I believe certain determinations of the amount of leakage from the canal have been made, and these should also provide a valuable indication as to whether it decreases or not.

25. I will now consider the possible methods of remedying the evil. In his notes Mr. Ozanne suggests drainage.

When land is water-logged, drainage is generally the proper remedy. But land is generally water-logged owing to surface drainage finding its way into some basin (if I may use the term) or into such an area in which, although the surface may be flat, the impervious sub-soil forms a basin, and out of which the water can only pass over the side. The usual method is then to make openings in the sides and let the water out. In such cases, however, the quantity of water passing in is less than that which can be made to pass out in the way indicated. The case under consideration seems to me to be different from that usually met with. As I examined the Baramati area, perhaps more carefully than any of the others, I will refer to it primarily.

In fields Nos. 239, 243 and 245 there are drains every 50-100 yards, and these are simply carrying off as much water as will run into them. The soil is, moreover, one which would, if it had an opportunity, easily drain itself; it is a fairly open soil and would not under ordinary conditions become water-logged. Moreover, it slopes away to the *nalla*. But it appeared to me that as fast as it let the water through, as much more came from the canal to replace it; in fact that the supply of water was never ending. If I am right in this conclusion, the more the land is drained the more water would leak in from the canal, and I, therefore, doubt if the method would be successful. But in addition to this there is the cost of drainage which is very great, and I raise the question whether drains could be laid

for any sum which would be recovered. Circumstances naturally alter cases, and it would manifestly be a mistake to make the sweeping assertion that drainage would do no good in any of the areas, even of those which I visited. At Baramati, however, I came to the conclusion that, however much the land might be drained, so fast would water come in from the canal. Very much the same conclusions forced themselves upon me as I visited the other areas.

At Pimpli, for instance, the people have cut a drain down field No. 22 to the *nalla*, but, although it carries away the water as it passes into it, the benefit is not perceptible ; for the land is as bad as ever it was, and the soil (see notes) in the area of the drain is so bad that it is not safe to go near it. If the drainage were effecting a remedy, the soil near the drain should be drier than elsewhere. However, at field No. 139 in village Hol (by Wadgaon Bungalow) the people are trying drainage and it will be possible to observe here if any benefit ensues.

26. I must now refer to another point which I have mentioned, namely, the erosive action of storm water. In his notes Mr. Ozanne remarks that the people are putting up *bunds*, and that it is the very worst thing possible. The remark has only reference to the effect it may have on the drainage of the land and has no reference to the erosion. Even from Mr. Ozanne's point of view I cannot quite agree with him. We have here to do with water which percolates from the canal, that is, from *below*, not from above, the surface ; and although *bunds* would undoubtedly prevent some surface water from passing away at times during the monsoon, they will not interfere with sub-soil drainage of the canal water. The rainfall of this district (see Statistical Atlas of Bombay Presidency) is distinctly light. At Baramati it averages 22·7 inches, at Supa 20·3 inches, and at Indapur 24·8 inches ; the major part of this being spread over five months. But to my mind the people are not altogether wrong in making these *bunds*. The erosion is especially serious in these affected areas, which, as I have pointed out, are all *nallas* or drainage channels, containing what is probably the best soil and the deepest, and the people naturally wish to prevent the loss which they see going on. I saw many of these *bunds* and they are common to the country. Some had given way under the pressure of water. No doubt, owing to the condition of the soil, less rain-water soaks in than would otherwise be the case, and the *bunds* have more water to withstand.

Indeed this erosion must be considered only second to the leakage from the canal ; for not only is good soil being carried off and unculturable channels or ravines being formed, but it appears to me that there is also another evil. It is here that the leakage from the canal seems to be greater than elsewhere : the height of the water above the surface of the land is greatest and this difference is becoming greater ; or, in other words, the stratum of soil intervening between the canal water is gradually being lessened, and the important question arises, whether, as this process continues, the leakage will not increase ? I think it is a point worthy of consideration.

27. I have said that the people have good reason for making *bunds*.

The only further question which occurs to me is, whether these are *bunds* of the best description. They are simply earthen embankments carried across the drainage channels and would have to withstand a great weight of water whenever rain fell. In a note, *Agricultural Ledger No. 16 of 1894*, I have described a method of reclaiming ravine land, which Captain Chapman, on whose estate in Oudh I saw it, has called "Back terracing," and it has occurred to me whether this would not usefully replace these embankments which the people at present employ. I think the experiment might with advantage be made. In this case there is never any great weight of water to be withstood and the surface washing is reduced to a minimum.

28. It remains only for me now to consider the question whether any crops may be tried to be grown on these lands in their present state.

From my notes it will be seen that *babúl* and *tarwad* are growing healthily in most of the fields I examined. If only these could be grown it would be better than nothing; for if they provide little in the way of revenue, they not only prevent erosion, but by the action of their roots would probably open up the soil to the passage of some of the water.

But in addition to these I have met with three cases where crops are growing on these water-logged lands.

In field No. 233, Baramati, I found a small plantain grove: this looked healthy, and it is significant to notice that it has been doubled in size this year.

The second case that I met with was in field No. 262 at Karanje, where sugar-cane now is growing, although the field, like all around it, was thrown out of cultivation at first. The crop looked well, although it varied somewhat in height as might be expected.

The third case that came under my observation was at Nimbut where the people had tried rice in one field and it had succeeded, as the Canal Supervisor told me, better than any one expected.

The same crop or the same remedy may not prove effectual in all cases, but it seems to me most desirable that every encouragement should be given to the people in these affected tracts to grow something on the land, if that be only *babúl* trees.

29. Samples of soil were taken from certain of the fields and the following are the notes and analyses relating to them.

Baramati.—Field No. 229: This lies to the west side of the *nalla*. The only part of this which is now cultivated is the corner farthest from the river and *nalla*. The rest is waste; *babúls* (Acacia arabica) grow well and there is some grazing, but a very large part is barren, water-logged and salty. The soil is "black" (*regur*) and stony.

	Sodium Carbonate.	Sodium Sulphate.	Sodium Chloride.
	Per cent.	Per cent.	Per cent.
"A." Surface Soil . .	*Nil.*	·02	7·53
"B." Sub-soil .	*Nil.*	·299	3·807

Field No. 243 : This field, which is situated near the canal, has a channel down the centre and another between it and the next field. Sample D. is one of the first 12 inches of surface soil. Water commenced to trickle into the hole as soon as it was made. The upper half of the field is waste, with a few bushes of *tarwad* on it; the lower half is salty and swampy. The sample was taken from a spot where the salt appeared to be rather bad. The soil is *regur*.

	Sodium Carbonate.	Sodium Sulphate.	Sodium Chloride.
	Per cent.	Per cent.	Per cent.
D.	*Nil*	·096	·040

Village Hol.—Field No. 170 : A sample of soil E. was taken from a field of sugar-cane at a spot where the crop was not very good. Water seemed to lodge here occasionally.

Field No. 139 : This land adjoins field No. 170 and was affected by salty efflorescence. A sample G. was taken to a depth of 2 feet in the badly affected area.

Salts.—Three samples of the salts (with accompanying earth) were taken where they had accumulated badly; they are marked H., K., and L. in the accompanying statement.

	Sodium Carbonate.	Sodium Sulphate.	Sodium Chloride.
E.	(Total Salts ·052 per cent.)		
G.	*Nil.*	·189	1·038
H.	*Nil.*	26·24	1·516
K.	*Nil.*	27·52	·91
L.	*Nil.*	29·07	·69

Two samples of the water from the Nira Canal contained 7·28 and 10·08 grains of salts per gallon respectively, which consisted principally of Sodium and Magnesium Sulphates with only half a grain of Sodium Chloride.

Regarding these samples it will be seen that the salts *in the soils* consist of Sodium Sulphate and Chloride, the latter generally predominating. The salts H., K., L., were principally Sodium Sulphate, but this accumulation of the one salt at the surface has probably been controlled by conditions of crystallisation. Sodium Carbonate was absent from all the samples.

THE AMOUNT OF SALTS IN GOOD SOILS.

30. It seemed desirable to determine the amount of soluble Sodium salts which are usually present in good soils in order to form an opinion as to how much these *usar* lands contain in excess of that which may be considered normal.

As has become evident, really bad *usar* may contain from 1 to 2 per cent. of these salts in the first 6 inches of surface soil, but there is much *usar* land which contains considerably less than this amount.

The following statement exhibits the analyses which have been made to this end, from which it will be seen that although a small proportion of these Sodium salts forms a normal constituent of soils generally, as indeed might have been anticipated, the amount is usually quite small. The soil from village Mohammadpur,

Muzaffargarh District, was situated near land which was visibly affected by salts and it contained doubtless more than good soils do as a rule. It was nevertheless a piece of good land near the village and regularly cultivated.

The three samples of clay were analysed with a view to finding out if clays usually contain more soluble salts than arable land. Those from Dehra Dun and Cawnpur contained practically none. In that from Saharanpur there was certainly some appreciable amount though not much.

It will be evident, however, that good arable soils and clays rarely contain as much as ·1 per cent. of total Soluble Sodium Salts, and generally the amount is much less than this. Further it may be assumed that all the three salts, namely, Carbonate, Sulphate and Chloride of Sodium are commonly, though not always, present in such land.

POT CULTURES AND THE AMOUNT OF SALTS WHICH WILL DESTROY PLANT LIFE.

31. In 1895 and 1896 I attempted to determine which of the three salts, so constantly present in *usar* soils, is the most prejudicial to plant life. Good garden soil was taken and with it each of the three salts, Sodium Carbonate, Sulphate and Chloride, were mixed in the proportions ·1, ·2, ·4, ·7, and 1·0 per cent. On each occasion the plants were also grown in the soil without any salt. In the first year Maize, Gram, Wheat, Barley and Peas were sown in these artificial *usar* soils, and in the second year Maize, Cotton and *Arhar*, and Wheat, Barley and Gram.

The first set of experiments were made in small garden pots, the second in moderately sized boxes. The soils were kept moist by almost daily additions of distilled water, but the amount of this had to be kept down to a small limit, for of course no drainage could be permitted.

32. From these experiments one or two general conclusions may be drawn.

The only mixtures in which plant life was immediately destroyed were those soils which contained ·7 and 1·0 per cent. of Sodium Carbonate. In the presence of this amount of the salt generally speaking, a few seeds only germinated at all, and the plants died off in the course of a few days. In all other cases the salts, *i.e.*, Sodium Carbonate up to ·4 per cent. and Sulphate and Chloride up to 1·0 per cent. were not generally immediately fatal, though in many cases the plants died off later.

The effect of the salts on the germination was generally to retard it rather than to prevent it altogether.

In the case of the cereals, Maize, Wheat and Barley, the germination was first seriously affected by ·7 per cent. Sodium Carbonate or Sodium Sulphate. In one case Maize and Barley were held back by ·2 per cent. Sodium Chloride, but in the other cases this effect was only produced by ·4 per cent. of Sodium Chloride. The germination of cotton was affected by a like quantity. The germination of the

Salts in Good Soils.

	20-93.	430-94.	457-94.	460-94.	402-95.	408-95.	409-95.	417.			
	Is on Sand Belt Good Soil.	Banthra, Lucknow. Good Soil.	Bahraich. Surface Soil.	Babraich. Surface Soil.	Mohammadpur, Muzaffargarh, Panjab.	Average clay land on Chenab Canal.	Average loam, Chenab Canal.	Good loam, Kaliki.	Clay, Dehra Dun.	Clay, Saharanpur.	Clay, Cawnpur.
Sodium Carbonate	...	·010	·005	·011	...	·041	...	...	·004	·033	·019
Sodium Sulphate	...	·007	...	...	·088	...	...	...	·006	·076	*Nil.*
Sodium Chloride	...	·011	·007	·007	·052	...	·005	·029	*Nil.*	·014	*Nil.*
TOTAL SALTS	·076	...	...	...	...	...	...	...	...	...	...

R, 67-70.

leguminous plants, Gram, Peas and *Arhar*, was interfered with by a somewhat smaller amount of the salts; ·2 to ·4 per cent. Sodium Carbonate, or Sodium Chloride, being sufficient to do harm, whilst of Sodium Sulphate ·7 per cent. generally proved harmful.

In the "after-growth" 0·2 per cent. Sodium Carbonate certainly caused harm in the majority of cases, though this amount did not actually prove fatal; ·4 per cent. was, however, quite fatal in the majority of cases.

The effect of Sodium Chloride was not quite as uniform as one might have wished. In the first experiments it proved unquestionably harmful in quantities so small as 0·1 per cent., but in the second series of experiments it did less harm and some of the plants grew in the presence of ·2 per cent. perfectly well.

Sodium Sulphate proved in both years to be less harmful than the Carbonate or Chloride, and in both the *kharif*, 1896, and the *rabi*, 1896-97, plants grew to the flowering stage in the presence of over ·5 per cent. of this salt.

Generally the leguminous plants suffered most readily, and of the cereals, Maize suffered least; this latter result *may* perhaps have been occasioned by the fact that more water was allowed to the plants in the *kharif* than in the *rabi*.

33. We may now compare these pot cultures with the conditions of fertility of some of the *usar* soils referred to in the former part of this paper.

Among the cases examined in the North-Western Provinces *usar*, at Kakwan (2 B.) we find grass growing in the presence of more than 1 per cent. of Sodium Carbonate in addition to smaller quantities of Sulphate and Chloride; at Ibrahimpur (3 B.) grass was growing in the presence of ·4 per cent. Sodium Carbonate. In the *usar* at Rasulabad (5) grass was growing in the presence of ·28 per cent. Sodium Carbonate and ·12 per cent. Sodium Sulphate.

At village Amramau (9) grass was growing in the presence of ·23 per cent. Sulphate in the surface soil and ·95 per cent. in the sub-soil. At Gursikran (14) grass was growing on the plots 35 and 24 which contained nearly ·2 per cent. Sodium Carbonate and about the same amount of Chloride. At Cherat grass is growing in the presence of as much as ·8 per cent. of Sodium Carbonate.

But although some grasses appear to exist in the presence of these amounts of salts, there is no evidence that cultivated crops can grow under such conditions. Analyses, as to the quantity of salts which seriously affect crops show fairly conclusively that so much may not be present without causing serious injury. In example 15 of the land at Gursikran it will be seen that wheat grew perfectly well in the presence of ·137 per cent. Sodium Carbonate in the top soil, but that it was destroyed by ·2 per cent. In example 5 at Rasulabad, a crop was growing perfectly in the presence of ·1 per cent. of Sodium Carbonate. At Mohammadpur, Muzaffargarh District, the soil contained ·088 Sodium Sulphate and ·052 Sodium Chloride, and, although no crop was on the field at the time, there was no doubt that it was regularly cultivated. Thus such evidence, as we have, indicates that crops

may be cultivated in the presence of ·1 per cent. of Sodium Carbonate, but that ·2 per cent. is sufficient to cause at least serious injury if not altogether to destroy the plant. There are no examples showing how much of the other salts may be present in a soil without doing serious harm.

34. The pot cultures which have been described indicate a conclusion in agreement with those made by American Chemists, namely, that the least harmful of these salts is the Sulphate and the most harmful the Carbonate. The Chloride is usually present only in subordinate amount.

The conclusion may, therefore, safely be drawn that the conversion of the Sodium Carbonate into Sulphate by the aid of gypsum would tend to minimise the evil effect of the Carbonate.

THE EFFECT OF CERTAIN SALTS, SUCH AS GYPSUM, ON USAR SOILS.

35. In a previous paragraph (3) of this paper I mentioned that one peculiarity of these *usar* soils is that they generally refuse to settle, after being stirred up with water. If, for instance, one part of an *usar* soil be shaken up with five parts of water, the sand of course settles immediately, but the clayey particles remain suspended in the water and days will often elapse before even the major portion of the clay subsides ; indeed in some instances this part of the soil has formed quite a thick *cream* with the water and has refused to settle at all. In any case the clay never subsides perfectly and at best there eventually remains an opalescent liquid. On the other hand, if a good soil be submitted to this process, it settles rapidly.

Again, if any good soil or even a clay be mixed with water and then thrown on a filter (say 100 grammes of soil with 500 c. c. of water on a 6-inch filter bed consisting of a perforated porcelain plate with a piece of cotton cloth over it, with a "fall" of 8 or 10 feet to hasten the process), it will generally happen (naturally) that the first portion passing through will be muddy; the filtrate, however, rapidly clears and the remainder of the water will pass through clear and quite rapidly, often in 5 minutes.

In the case of most *usar* soils, however, this is not the case. With them it usually happens that muddy water comes through the filter bed for a considerable time, the process of filtration rapidly becomes slow, and although the water frequently eventually passes through clear, this is by no means always the case, and it is quite as common for the liquid which comes through to be *opalescent*. Again the process of filtration is usually *very* much slower than is the case with good arable land or clays. It may continue for an hour or two, or it may and frequently does take days for all the water to pass ; it also often happens that the filtering process stops altogether at the end of a few hours.

If it be recollected that the quantity of soil named forms a layer of only about ¼ inch on the filter, that the water used measures only about 2½ inches and that the filtration referred to takes place under a pressure of 8 or 10 feet of water, it will be evident that *physically*

as well as chemically, these soils differ from ordinary good soils. It will also be at once apparent that in the case of such soils ordinary drainage conditions must have ceased to exist.

36. In the case of one of the soils which had yielded an opalescent extract, I wished to observe microscopically what its condition was, and after finding that it contained *solid* particles, I proceeded to see if they would become precipitated by the addition of salts in the same way as an acid causes many such light floating particles to subside. I added solution of Calcium Sulphate (gypsum). It acted perfectly and in a very few minutes the particles collected together and gradually subsided. The same thing occurred in a test tube and it was at once apparent that a clear extract of the soil could be obtained by this means. The cause of this effect was the next thing I studied, and one of the first questions which occurred to me was whether this subsidence of the particles had any relation to the effect which the Calcium Sulphate must have had on the Sodium Carbonate present in the extract. When solution of Calcium Sulphate is added to one of Sodium Carbonate, a simple chemical change occurs and Calcium Carbonate and Sodium Sulphate are formed.

In the next place I found that small quantities of such salts as Calcium Chloride and Barium Chloride, which also re-act in a similar manner with Sodium Carbonate, forming neutral salts, had precisely the same effect and precipitated the particles from the opalescent extract of the *usar* soil.

Experiments were now made on the entire soils. I added these salts to severai *usar* soils (in water) which had filtered badly and I then found that the clayey particles simply coagulated in a most extraordinary manner and the whole very shortly subsided leaving the water perfectly clear and colourless. Moreover, after this treatment, the soils allowed filtration to proceed rapidly and perfectly. This effect was quite uniform in the case of the soils experimented with.

Other salts, such as Sodium Chloride and Sodium Sulphate, will likewise precipitate these *usar* soils. But the amount of them required for the purpose is very much larger than is the case with salts which re-act chemically with Sodium Carbonate, and the solution requires to be fairly concentrated.

The change was so sudden and generally complete that it seemed likely that it would occur suddenly after a *certain* definite quantity of the Calcium or Barium salt has been added.

37. I now carried out a quantitative experiment with a view to determining whether this peculiar curdling effect had any relation to the amount of Sodium Carbonate present. For this purpose I selected a set of soils in which the amount of Sodium Carbonate and other salts had been determined. It will be evident that if any relation exist between the curdling of the soil and the Sodium Carbonate present, the soil should coagulate when enough Calcium or Barium salt had been added to completely decompose the Sodium Carbonate. In each case the experiment was made as follows: 10 grammes of the soil was shaken up with 80 c.c. of

distilled water in a glass cylinder. Solution (of known strength) of the Calcium Sulphate, Calcium Chloride or Barium Chloride, as the case might be, was then added from a graduated burette to the soil and water, in small quantities at a time, and after shaking the soil and water, the cylinder was allowed to stand some 10 or 15 minutes between each addition of the salt in order to allow the effect to be observed. As soon as the coagulation became apparent, the quantity of the added Calcium or Barium salt was noted, and this quantity then calculated into its equivalent of Sodium Carbonate.

The results of this set experiments are set out in the accompanying statement, in which are also entered in the top line the amount of Sodium Carbonate which had been found by analysis. In four cases (Nos. 304, 305, 307, and 311) the amount of gypsum or other salt required to produce the coagulation was appreciably in excess of the amount of Sodium Carbonate present, but in the other eight cases the amounts approximate quite as closely as the circumstances of the experiments would admit. It is to be expected that an excess of the gypsum or other salt would be added before the coagulation occurred, and, moreover, this change is naturally not so perfect an indicator as is the case, for example, in alkalimetry, where a colouring matter is employed. But the experiment does indicate, I think, a very close connection between the coagulation and the amount of Sodium Carbonate, so much so that the conclusion may be drawn that it is due to the Sodium Carbonate that these soils generally offer so little facility to the passage of water and consequently hinder to a very great extent the natural process of drainage.

Statement showing the amounts per cent. (in terms of Sodium Carbonate) of certain Salts required to cause coagulation of Usar Soils.

No.	304.	305.	306.	307.	308.	309.	310.	311.	312.	313.	314.	315.
Sodium Carbonate present	·044	·068	·072	·193	·416	·24[illegible]	·137	·04[illegible]	·340	·251	·332	·237
Calcium Sulphate . .	·145	·165	·103	·373	·393	·290	·207	·352	·310	·310	·372	·372
Calcium Chloride . .	·104	·145	·083	·270	·291	·270	·145	·125	·250	·250	·333	·353
Barium Chloride	·127	·148	·106	·339	·38[illegible]	·212	·191	·169	·275	·297	·399	·399

38. But the most important practical conclusion which may be deduced from the foregoing series of experiments is the physical effect which gypsum has on these soils. It has been seen that this same effect is produced by other salts. So far as the Calcium Chloride and Barium Chloride are concerned, they may be now left out of consideration. They were merely included in the experiments to prove the general effect which those salts, which re-act with Sodium Carbonate, have on these soils. They are, however, not only far too expensive materials to think of employing them on the large scale, but also more or less prejudicial to plant life. Gypsum, however,

is a material which occurs in large amount in various parts of India, in the Himálaya, Salt Range, Central India, etc., and although, as will become presently evident, even then an expensive "cure" for *usar* land, it need not on that account be summarily dismissed from further consideration. It is likewise a substance which would do no harm to crops if present in even very much greater quantity than that now to be considered. Since it appears to be the case that an amount of gypsum is required by these soils to coagulate them, closely approximating to the amount of Sodium Carbonate present, we may calculate the amount of gypsum required to cure, or at least to open up to drainage water, certain land, the analyses of which have been quoted in the previous paragraphs.

It is necessary in the first place to know the weight of soil per acre which has to be dealt with, and from it to calculate the amount of gypsum equivalent to the Sodium Carbonate. A little consideration will show that it is not necessary to know this exactly, for in the first place the amount of salts in *usar* soils varies rapidly as is shown in some of the examples previously quoted, and secondly one does not know how far down the salts descend in the sub-soil, although the analyses quoted in this paper indicate that they are principally situated in the surface soil.

The weight of clay soil (in the dry state) per acre to a depth of 9 inches is stated by Warington to vary from 3 to 3·5 million pounds, which becomes 4 to 4·7 million pounds to the depth of 1 foot. Schubler calculated heavy clay land to weigh 3·25 million pounds to a depth of 1 foot. Some weighments which Mr. Sabbiah, Principal of the Agricultural School, Cawnpur, made for me, showed that the first 6 inches of a field which is in good manurial condition weighed 2·1 million pounds, the next 6 inches, however, was equal to 2·35 million pounds. In another field which was in poor condition, the first 6 inches of surface soil was equal to 2·42 million pounds per acre and the next 6 inches to 2·51 million pounds. Thus the first foot of soil in the good field works out to 4·45 million pounds, and that of the field in poor condition to 4·93, figures which are higher than what Schubler found, but approximate to those published by Warington. Assuming then that the *usar* land of the alluvial plains is generally similar to the field in poor condition or, say, 5 million pounds per acre for the first foot, and assuming a case in which the soil contains ·2 per cent. of Sodium Carbonate in the first foot, this will amount to 10,000lb of Sodium Carbonate. The amount of gypsum required to change this to Sulphate would be 16,000lb or (say) 200 maunds, and allowing ·1 per cent. of Sodium Carbonate for the second foot of soil the amount of gypsum required for the first 2 feet in the field comes to 300 maunds per acre. This is of course a large amount and would probably cost nearly as much as the land is worth. But there are doubtless very many fields more or less under cultivation, but sterile in parts, which might be cured by an application of a smaller amount of gypsum than that above mentioned. It may be of course that in practice it will be found sometimes unnecessary to neutralise the whole of the

Sodium Carbonate. For instance in a part of the *Usar* Reserve at Aligarh wheat grew perfectly in soil containing ·137 per cent. of Sodium Carbonate in the surface soil (*vide* paragraph 4), and if it should prove sufficient to reduce the quantity of Sodium Carbonate to 0·1 per cent., the cost would be much less than if the whole had to be converted into Sodium Sulphate.

In the case of some soils which I have treated with an amount of gypsum insufficient to convert the whole of the Sodium Carbonate, apparently the "coagulation" process had commenced, and the soil allowed water to pass more freely than before the treatment, but nevertheless more slowly than after the full equivalent of gypsum had been added.

Up to the present the experiments have been on a Laboratory scale only, but field experiments are now being commenced in the North-Western Provinces and the matter put on a practical footing. At any rate it may be safely assumed that in no case will any material benefit ensue from the application of merely 2 or 3 maunds of gypsum per acre.

39. Regarding the best method of applying gypsum, whether it will be necessary to grind it up to a powdery condition or whether it will be sufficient to break it into pieces the size of an egg; how deeply the land should be ploughed at the time of application, to what degree it may be advisable to mix the soil with the gypsum; how long it will take the gypsum to produce any effect on the subsoil, are also questions which can only be answered by practical experiment.

One or two things may, however, be noted. The first is that gypsum is not very soluble in water, and that it is only after it becomes *dissolved* that it can exercise the physical and chemical effects which have been described. One part of gypsum requires 400 parts of water to dissolve it, and, as a very simple calculation shows, 6 inches of water on an acre of land weighs 1,360,000℔, this allowance of water would dissolve some 3,400℔ or about 40 maunds of gypsum. Much more than 6 inches of water cannot be put on land (by the aid of *bunds* of course) at one time, and consequently 6 inches of water would not dissolve a dressing of 200 or 300 maunds of gypsum at once.

But these calculations are valuable rather to show that a large amount of water would be desirable to assist in bringing the gypsum into a condition in which it can take effect, than to determine the absolute amount of water which might be necessary in any one case. The process which would follow the application of (say) gypsum in lumps the size of a nut on ploughed land may be pictured as follows. Water having been applied, it would dissolve the Sodium Carbonate in the surface soil and a small quantity of gypsum; that portion of gypsum which is then in solution re-acts with the Sodium Carbonate. Sodium Sulphate (a very soluble salt) and Calcium Carbonate are produced. The fact of the water now containing these two new salts does not prevent it from dissolving any more gypsum. On the contrary, this same water may now proceed to dissolve up another lot of

gypsum, which in its turn re-acts with more Sodium Carbonate and the process, so far as the water is concerned, might go on repeatedly.

But another circumstance plays an important part. Supposing some gypsum be placed at the bottom of a vessel and a solution of Sodium Carbonate poured upon it to a depth of several inches. The Sodium Carbonate which is in the immediate neighbourhood of the gypsum would re-act with it at once, but if the vessel be left at rest, the Sodium Carbonate in the upper strata of the vessel would only come into contact with gypsum very slowly, and consequently a considerable time would elapse ere the change between the whole of the gypsum and Carbonate became complete. If, on the other hand, means be employed to bring the Carbonate rapidly into contact with the gypsum, the change would proceed quickly. For instance, this would be the case if the vessel were constantly shaken.

Applying this to the supposed field experiment it may be assumed that if the land were ploughed (as is done for rice) whilst the water is in the *kiaris*, the rate at which the gypsum would be able to effect the desired chemical change in the Sodium Carbonate, and the physical one in the soil, would be materially augmented.

Incidentally this process of ploughing would probably assist in overcoming another difficulty.

Taking again the case of the lumps of gypsum in the glass vessel of Sodium Carbonate solution. As pointed out, in the first instance, the Carbonate touching the lumps of gypsum re-acts with the latter and there is produced Calcium Carbonate, and this is formed in part at least actually *at the surface* of each lump of gypsum. Calcium Carbonate is a very insoluble substance, much less soluble at least than the gypsum. The consequence is that on each lump of gypsum there is liable to be produced a covering of Calcium Carbonate, and this would, unless otherwise prevented, act as a sheath and stop the Sodium Carbonate and gypsum from coming into further contact with each other. Agitation and rubbing the lumps against each other or against other hard materials would break up such covering of Calcium Carbonate, and similarly ploughing the land would also assist in producing this effect.

Then, too, the smaller the lumps of gypsum, the larger will be the surface in contact with the water and, consequently, with the Sodium Carbonate.

Thus it will be seen that a plentiful supply of water, coupled with ploughing, may materially assist in giving the gypsum the opportunity to work its effect.

40. These considerations have to do principally with the surface soil. In the case of the sub-soil, where the plough cannot work and where (in such soils as are more or less impervious *at first* to water) the water cannot readily carry the gypsum, it is impossible to do much to assist matters. That the process will be slow is quite possible, if not probable. But having brought the gypsum into contact with the surface soil and thus causing those physical and chemical changes to take place which have been described, we may "rest on our oars" as it were. We have destroyed the Sodium Carbonate

in the surface soil and have provided a supply of gypsum for that which is in the sub-soil. If water brings the latter upwards, it is at once met by the gypsum and destroyed. If the irrigation water can penetrate the sub-soil it will carry some gypsum with it. Whilst the process is going on, some sort of a crop might be persuaded to grow in the surface soil.

The foregoing is a picture of what is *likely* to happen, drawn purely from a knowledge of the properties of the materials concerned.

41. One thing more may be alluded to. It has been fully explained, that the effect of gypsum is not to carry the Sodium Carbonate away, but to change it into another salt—the Sulphate. This, though less pernicious than the Carbonate, is nevertheless not harmless to plant life. Moreover, in many *usar* soils there exist also the Sulphate and Chloride of Sodium. To effect a perfect cure of *usar* it is necessary to *actually remove* these salts. If, as the Laboratory experiments already enumerated show, the soil, after treatment with gypsum, becomes pervious to water and drainage conditions establish themselves, it may then be hoped that these salts will be washed away from the reach of plant roots.

42. It has been suggested by some that underneath these *usar* lands are "pans" of impervious strata which are the cause of the very imperfect drainage. So far as I am aware, no single case has been described in which such a "pan" exists. Moreover, although I have searched for them in cuttings and river banks in the neighbourhood of *usar* plains, I have never been able to observe them. Nor is it altogether conceivable that such a state of things is the general cause of *usar* land. Some of these plains are of large extent and the "pan" corresponding to them would have to be very large indeed. Then, too, is such an explanation compatible with the existence of all the small patches of *usar* which occur in cultivated fields? Of course such a discussion is purely hypothetical and without supporting evidence.

On the other hand, the simple fact of these soils being frequently so impervious to water, as is proved by the filtration experiment described in paragraph 35, is quite sufficient to explain why the salts are not washed down, as is regularly the case in the cultivated areas. It must be admitted as at least possible that if this physical change (which gypsum undoubtedly effects on these soils) can be realised, one might confidently hope that the salts would be washed (more or less rapidly) into the sub-soil and away from the plants.

THE EFFECT OF ENCLOSING USAR LAND FROM GRAZING.

43. It has already been pointed out in paragraph 5 that where there is any material quantity of salts in *usar* soils, the major portion is situated in the first few inches of the surface soil.

In 1885 two considerable areas of *usar* land were taken up by the Agricultural Department, North-Western Provinces and Oudh,

near Aligarh. The one is situated at village Gursikran and has an area of 718 acres, the other at Cherat and measures 241 acres.

44. Various experiments were made at the latter place such as planting of trees and scraping off the salts annually, but the principal object with which both these areas were taken up was to see what would be the effect of enclosing the land from grazing. It was suggested that by this means the natural grasses might establish themselves again. Accordingly a fence was put round each and grazing prohibited. The immediate outcome of this procedure was a rapid growth of grass. In reporting on this point the Director, Botanical Department, Northern India, writes in 1887 with reference to Gursikran: "The prevailing grass is *kar-usara* which over the large portions of the ground grows in great luxuriance unmixed with any other kind of vegetation. Some of the blocks are almost entirely bare and efflorescent; others contain nothing but *usar* grass; whilst in others there is a mixed vegetation, including various sized patches of *dub* grass which appears to be rapidly spreading. All these various conditions present a corresponding series of changes which the vegetation over the whole area has been undergoing during the time it has been enclosed and protected."

And regarding the area at Cherat the same officer reports: "The effect of enclosing this piece of land, even for so short a time, has been directly beneficial in stimulating the growth of the natural grasses. The *kar-usara* or *usar* grass (a species of **Sporobolus**) is rapidly extending over parts that were absolutely bare, whilst *dub* **(Cynodon dactylon)** and other valuable fodder grasses are spreading in proportion."

As the grasses extended, the salts apparently disappeared from the surface more or less, and the question naturally occurred, "Are the grass roots opening up the soil so as to re-establish natural drainage conditions?"

45. No samples of the soil of either of these "*usar* Reserves" were selected when the land was first taken up, and the only evidence of their former condition which was at my disposal when I visited Aligarh in 1893 were some illustrated sketches and notes which Mr. Duthie had made shortly after the land was enclosed and which he very kindly lent me.

From these, however, it was possible to find spots which were not only devoid of grasses in 1888, but on which a plentiful crop of *Reh* was present.

Judging by the analyses of land covered with *Reh*, which have been already quoted, one may assume that the amount of salt must have been something approaching 1·0 per cent.

In 1893, the grasses had spread over plot 35 and no salt was visible. Plot 24 was one of several on which rain water had been annually retained by means of an embankment, and the land was destitute of grass, but there was also no visible sign of salt.

The analyses have already been detailed in paragraph 4 (14), and it will be seen that not only is there comparatively little salt in the surface soil, but that the amount *increases* somewhat in the sub-soil

of plot 35. In the land outside the *usar* Reserve [*vide* 4 (14)] there was considerably more salt in the surface and sub-soil than in that of the two plots named. Again at the second place in this *usar* Reserve [*vide* 4 (15)] from which samples have been analysed, it will be seen that there is less salt in the surface than in the sub-soil. Finally at Cherat where grazing has been excluded and the grasses encouraged, much the same thing is evident; there is as much salt in the sub-soil as in the surface soil.

46. It would seem clear, therefore, that the enclosure from grazing and the consequent growth of grass has caused the salts to become diffused into the sub-soil, and, although the process is a very slow one, one might anticipate that eventually these salts may become spread throughout such a depth of soil as to reduce that in the surface to a quantity which will no longer prevent the growth of crops.

47. ***Conclusion.***—The conclusions which may be drawn from the foregoing work may now be briefly summarised:—

(1) The presence of an injurious amount of Sodium Salts in the surface soil is not confined to land in the North-Western Provinces and Oudh and the Panjab, but the same phenomenon has established itself in at least two other places in the Bombay Presidency. It would appear probable, however, that the occurrence of the salts in the black soil tracts in the neighbourhood of the Nira Canal is due solely to percolation from the canal.

(2) In the North-Western Provinces and Oudh the salt which is usually present in largest amount is the Carbonate. In the Muzaffargarh District of the Panjab and on certain lands in the neighbourhood of the Chenab Canal, the principal salt is likewise the Carbonate. In the Ferozepur District, at Lahore, and on the upper part of the Chenab Canal area, the salt which is usually present in greatest amount is the Sulphate.

In the *usar* land of the Kaira District, Gujarat, and in the land on the Nira Canal the principal salt is the Chloride.

(3) These Sodium Salts are almost uniformly concentrated in the first few inches of surface soil, the amount in the sub-soil being generally considerably less.

(4) The amount of Sodium Salts in the surface soil of *bad usar* land rarely exceeds 2 per cent. and is often much less.

(5) All the three Sodium Salts, Carbonate, Sulphate and Chloride, are commonly present in good arable land and in clays; the amount of them is, however, usually quite small, sometimes rising to as much as one-tenth per cent., but generally to much less than this.

(6) Enclosing land from grazing and thus encouraging the grasses to grow, causes, or allows, the salts to descend from the surface soil and to become distributed in the sub-soil; the rate at which this distribution occurs is not known, but it is evidently slow.

(7) The pot-culture experiments which have been made, indicate that ·2 per cent. of Sodium Carbonate causes injury to cultivated plants and this result is incidentally confirmed by certain examples taken from the soils of fields. Of Sodium Chloride, ·2 per cent. probably does harm; ·4 per cent. is certainly pernicious. Of Sodium

Sulphate, ·5 per cent. is probably not harmful to cereals. Plants of the leguminous order appear to be more readily affected by Sodium Salts than are the cereals.

(8) The very imperfect conditions of drainage, which exist in *usar* lands are probably occasioned not by an impervious "pan" below ground, as has been assumed by some, but by the condition in which these *usar* soils have arrived. The cause of this condition is probably the Sodium Carbonate present; if the Sodium Carbonate be destroyed, these soils become pervious to water and admit of rapid drainage.

The Sodium Carbonate may be destroyed by various means; one, which is perfectly successful, consists in the application of gypsum to the soil.

But whether it would be necessary to apply enough gypsum to convert the whole of the Sodium Carbonate into Sulphate, or whether a less quantity would prove sufficient, remains to be demonstrated by field experiments.

G. I. C. P. O.—No. 294 R. & A.—13- 1-97.—2,200.—W. B. G.

(Forest Series No. 3.)

(Timbers.)

THE AGRICULTURAL LEDGER.

1897—No. 14.

TECTONA GRANDIS.

(TEAK.)

[*Dictionary of Economic Products, Vol. VI., Pt. IV.*, T. 232—67.]

PRODUCTION OF AND TRADE IN TEAK WOOD.

'*Report and Working Scheme of the Nilambúr Teak Plantations,' by* P. M. LUSHINGTON, ESQ., *Deputy Conservator of Forests. Review of certain passages by* THE EDITOR.

NILAMBUR PLANTATIONS.

Mr. P. M. Lushington's *Report on the Nilambúr Plantations* (published under cover of Resolution No. 258 of the 10th June 1896 by the Madras Board of Revenue) will doubtless (by those interested in the production of and trade in TEAK WOOD) be regarded as a valuable contribution to the literature of the subject, besides being an instructive essay on the Commercial Aspects of Timber Plantations generally. The following passages may, therefore, be abstracted as exemplifying some of the more practical conclusions arrived at by Mr. Lushington :—

Suggestion of their Formation, 1840.

History.—"The Nilambúr teak plantations were first suggested in 1840 by Mr. Conolly, Collector of Malabar, who described their object as being to replace those forests which have vanished from private carelessness and rapacity—a work too new, too extensive and too barren of early return to be ever taken up by the native proprietor.

"The plantations owed their existence to the accident that one of the many religious bodies holding temple lands happened to be in want of funds and to own blocks of land scattered here and there in

NILAMBUR TEAK PLANTATIONS.

this valley, many of which constituted the very best sites for planting that could have been selected had the whole area been available to choose from.

"At first considerable difficulty was experienced in making the teak seeds germinate and Mr. Conolly, in a letter of the 4th August 1842, reported that of 30,000 seeds sown, none had come up and that of 10,000 saplings transplanted, more than half had died. At the end of 1843, the true method was suggested by Dr. Roxburgh, and this method, with a few slight modifications, is continued up to the present day."

Position : Climate : Soil (p. 41).—"The plantations lie in the Nilambúr valley surrounded by hills of Sisapara on the south-east, the Wynaad (S.E.) on the north-east, and the Camel's Hump on the north-west side. The plantations all lie in the Nilambúr range of South Malabar District." "The distinguishing characteristic of the Nilambúr climate is its damp heat so favourable to rapid growth. The temperature in shade ranges from 75° to 95°. The average rainfall for the past ten years is 94·5 inches." Mr. Lushington explains that the soil of the plantation is very varied, alluvium overlying gneiss rock or laterite derived from the hills. The observation has been recorded that the teak growing on alluvial soils was of first class; that on laterite, second class. Further, that damp alluvial soils were not favourable, though these were improvable by drainage.

Demands for Produce (pages 45—47).—"The teak plantations yield marketable products of three kinds:—

Final Crop.

(1) The timber which will be furnished by the final crop and also during the later thinnings.—For this, there is a large demand, and there is no doubt that all this first-class timber will sell at a very large rate. The superiority of Malabar teak is so well known that it is probable much of this timber will go into the Bombay, and even into European markets. At present, however, there is no doubt that the best prices will be given by the Arabs who require it for their ship-building in lengths as long as possible, so that the plantation teak is specially suited to their requirements. At present really good Malabar teak is selling at R3-8 to R4 per cubic foot in Calicut, whilst Burmah teak in Bombay only realizes R2 or a little more. At present the Arabs obtain their supplies from Cochin and Travancore, but the teak they obtain is inferior, and there is no doubt that, when the plantation becomes

Prices.

NILAMBUR TEAK PLANTATIONS.

exploitable, the whole of this demand will fall on them. There is nothing to show that there is any limit to the demand for teak of this size and quality, and it is unlikely that the price of this teak, as it stands will ever become less than R2-8 to R3 per cubic foot."

Saplings.

(2). "***Teak saplings.***—They are divided into seven classes (1) measurables, (2) superior (small), then first, second, third, fourth and fifth classes. The first two classes are bought by Parsee merchants and Cutch traders. The timber of this class is usually exported to Bhowanagger, where it is used as beams for house building by the more well-to-do people. The price realized for this timber is decidedly good, averaging R2 per foot, but it seems doubtful whether there is a very large demand for such timber. The other classes of saplings are bought by the same traders and exported to different parts of Bombay, especially Bhowanagger, where there is a constant demand for about 40,000 saplings per annum, which occasionally rises to 60,000, but beyond this there is little or no demand at present. They are cut up and used for the rafters of native houses. The average prices realized for these classes during the last five years are :—

Prices.

	R	a.	p.	
Measurables	5	11	0	per sapling.
Superior, small . . .	3	4	0	
First class	2	5	0	
Second „	1	5	0	
Third „	0	12	0	
Fourth „	0	7	0	
Fifth „	0	3	0	

The following table shows the number of saplings sold during the last ten years under the old and revised working plan :—

Year.	Number.	Revenue. R	a.	p.
1885-86	53,562	59,766	8	10
1886-87	...	1,935	6	2
1887-88	49,079	32,441	12	4
1888-89	39,739	29,693	1	7
1889-90	39,560	26,165	9	10
1890-91	50,235	30,072	11	2
1891-92	31,258	24,596	5	2
1892-93	17,845	15,079	11	8
1893-94	22,952	32,044	12	10
1894-95	3,071	27,895	3	3

NILAMBUR TEAK PLANTATIONS.

"This includes—In 1893-94, 111 logs (1,124 cubic feet) realizing . R 2,072 } sold locally.
In 1894-95, 349 logs (7,076 cubic feet) realizing . 12,537

	R	
"This includes—In 1893-94, 111 logs (1,124 cubic feet) realizing .	2,072	sold locally.
In 1894-95, 349 logs (7,076 cubic feet) realizing .	12,537	
TOTAL .	14,609	

showing that there is a good demand for the larger timber taken out in thinnings.

"The present market demands special attention to two points:—

Conditions of Timber.

(*i*) That all big timber should be as long as possible, length being the special quality (with good breadth) required by the Arabs.

Girdling destroys the Oil.

(*ii*) That all timber must be cut and exported green and not seasoned or girdled, the reason of this being probably that salt water seasoning is preferable, and girdling destroys the essential oil for which Malabar timber is so celebrated. There is at present no demand for branch wood, so this cannot be taken into consideration in this plan.

Bamboos.

(3) "***Bamboos.***—Considerable quantities of bamboos are used yearly to float the saplings. At present only the indigenous bamboos are used and these sell at an average of R10 per hundred in Kallai. These will be replaced by the introduced bamboos from Burmah, when they become fit for cutting, and their large size should render them very valuable. At present, however, it cannot be stated what price they will realize."

Exports.

"***Lines of export.***—A main road runs close to the plantations into Calicut, but is not used for carting timber which can be transported by water so much more easily. Each block planted is served by one or more small rivers down which floating is possible from July to October and in some instances later. Floating in the main river below Mombat is easy at all times of the year. There are at present 25 young elephants attached to the district. The great majority of those have been caught locally and are being trained and are now doing all the work required of them in dragging the saplings to the river, and some are capable of moving larger logs in the Natural Forest. These will be invaluable when it comes to dragging the large timber in the final exploitations.

Employment of Elephants.

"The plantations recently put down have been carefully intersected with narrow roads, which are very valuable for inspection and will serve as drag-roads later. In any future planting, this should be

attended to, as want of them in places is much felt. In the older compartments this has, to a certain extent, been improved by keeping open the compartment boundary lines as fire lines. NILAMBUR TEAK PLANTATIONS.

"***Depots.***—The only regular depôt is at Kallai, a mile from Calicut, but temporary depôts are made in the forest itself and some of the wood is sold straight from the forest depôt. Sales from the plantation are good and should be encouraged as much as possible, and it may be found practicable later to abolish the Kallai depôt, though this cannot be done now." Depots.

Proposals for Future—(pp. 67—68).—"It is proposed for the future to treat both the old and new plantations under the same method, *i.e.*, a system of high forest with a clean felling of the final crop and artificial regeneration. The method to be accompanied by thinnings with a view to the improvement of the final crop. The felling to commence not earlier than the year in which the average girth at breast height will be 6 feet 6 inches. The measurements taken show that the centre girth will not be less than 4 feet 6 inches. On first class soils the final crop should consist of not less than 40 trees and on second class of not less than 50 per acre." Future Treatment. Number per acre.

"***The age of exploitability.***—This has been found out to be 95 years on first class and 140 years on second class soils, as worked out in the appendix." Age 95 years and 140 years.

"As the oldest plantation is only 50 years at present, no scheme for final fellings has been prepared. It has, however, been ascertained by employing the current rate of growth (the growth in the different blocks of plantation does not materially differ). Pannengode is for its age slightly the most advanced, and Amrampolliem is a little behind the others. The final fellings must be spread over a period of at least 50 years."

Determination of final yield.—"The total yield per acre on first class soils is 3,000 cubic feet per acre and on second class 2,000 cubic feet per acre. Yield.

"The annual yield, if spread over 50 years, will be 147,910 cubic feet of first-class and 73,780 cubic feet of second-class timber. According to the present market, this will fetch not less than R3 per cubic feet standing for first-class and R2 per cubic feet for second class. The total revenue to be derived will therefore be R4,43,730 + 1,47,560 = R5,91,290, or, with the net profit derived from miscellaneous sources such as third class bamboos, etc., may safely be fixed at 6 lakhs per annum.

TECTONA grandis.

Production of and Trade in Teak Wood.

NILAMBUR TEAK PLANTATIONS.

Founded, 1844.

The following passages (*pp. 138—139*) may now be given from the Resolution of the Board of Revenue on submitting Mr. Lushington's Report to the Madras Government:—"The plantations were at first started in 1844, but no attempts at systematic thinning were commenced until the year 1885. In that year the then Conservator (Colonel Campbell Walker) drew up, in conjunction with Messrs. Porter and Hadfield, a rough preliminary scheme to last for five years for regulating thinnings. This scheme was in operation until the year 1890-91, when it was revised by the same officer so as to last for another five years ending with 1895-96. (Inspection Report in Board's Proceedings, Forest No. 206, dated the 16th May 1891.)

Working Plan.

"Colonel Campbell Walker then suggested that, before the termination of the period covered by the revised scheme, a special officer or officers should be deputed to draw up, from the experience gained by the working of the preliminary schemes, a regular Working plan to provide not only for the thinnings but for final fellings; and in accordance with this suggestion, which was subsequently supported by Mr. H. A. Gass, Acting Conservator, in his inspection report embodied in Board's Proceedings, Forest No. 253, dated the 14th April 1894, Mr. P. M. Lushington was appointed to prepare the Working plan in question."

"Mr. Lushington's Report and Working scheme have been carefully prepared. He has collected much useful information and added to the Working scheme a complete report of the past history of the plantations. He does not, however, make provision in the scheme for final fellings, as the period for such fellings is estimated by him to be still too far off. It was hitherto anticipated that the trees would attain maturity after 60 years, so that the first planting, *viz.*, that of 1844, was expected to be felled in the year 1904. Mr. Lushington, after a careful calculation, disproves this theory and fixes the exploitable age at 95 years for first-class soils and 140 years for second-class soils. At this age he estimates that the trees will attain an average centre girth measurement of 4 feet 6 inches, which is the measurement most in demand in the market."

Final Felings, 1939.

"According to Mr. Lushington's proposals, therefore, the final fellings will not commence until the year 1939, when the first planting will have reached its 95th year. In the interval Mr. Lushington provides for thinnings, and estimates the annual average yield therefrom at R52,801 during the first five years and R80,247 during the next five years. Mr. Lushington's proposals for future treatment have the approval of the Conservator, and the Board resolves to accept them."

T. 232-67.

G. I. C. P. O.—No. 349 B. & A.—29-11-97.—2,200.—R. B.

(Agricultural Series, No. 23.)

THE

AGRICULTURAL LEDGER.

1897—No. 15.

MANURES AND MANURING.

(BONE-DUST MANURE.)

[*Dictionary of Economic Products, Vol. V.*, **M. 237-59.**]

UTILISATION OF BONE-DUST MANURE.

Extract from Correspondence between the Director of Land Records and Agriculture, Panjab, and the Senior Secretary to the Financial Commissioner, Panjab. With a note by the Editor.

Extract, paragraph 3, of letter No. 1213, dated 8th June 1897, from the Director of Land Records and Agriculture, Panjab, to the Senior Secretary to the Financial Commissioner, Panjab.

* * * * *

3. As regards (1) Utilisation of bone manure, it was mentioned in the reports of 1893-94 and 1894-95 that no further experiments had been made in the province with bone-dust manure. The mill for crushing bones started some years ago by Mr. Drummond, Deputy Commissioner, Karnal, in the Kunjpura estate, has been given up on the ground of expense and absence of demand for the bone manure, and the mill started at Lahore by the late Mr. Robson for crushing bones for export was closed some years ago on his death. Even when the mill was working there was no demand for the bone-dust locally for manure. The price (about R1-2-0 per maund at Lahore) was considered prohibitive by local agriculturists not accustomed to intensive farming, though farmers in England are willing to pay £5 to £6 per ton, say R3-4 per maund for the bone-dust as manure.

I am afraid that, while bone-dust manure is so costly according to native ideas and so long as the prejudice against its employment continues, especially among Hindu agriculturists, little can be done to check the exploitation of this valuable fertilising agency. It has, however, to be borne in mind that Indian soils are deficient rather in nitrogenous matters than in the phosphates which bone-dust is so

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MANURES & Manuring. Utilisation of Bone-dust Manure.

rich in, and bone-dust manure, which is so highly appreciated in Europe and America, has not been proved by experiment to produce equally good results in this country.

The exports of bones from Karachi which come mainly from the Panjab is meanwhile increasing with extraordinary rapidity as the following figures prove :—

Exports in cwts.

1892	. . .	186,500
1893	. . .	227,133
1894	. . .	338,691
1895	. . .	422,582
1896	. . .	493,844
1897	(up to 26th May)	271,286 (in five months).

No doubt it has been stimulated within the last two years by the great losses of cattle in this province from drought and starvation. The price at Karachi remains from at R1-10 to R1-12 per maund (84 lbs.) of dry uncrushed bones, and this year the value of the bone exported up to date is considerably greater than that of all food-grains exported.

[The above note will be read with interest as it draws attention to the fact that such a useful fertiliser as bone-dust is readily obtainable from an abundance of raw material which can be easily disintegrated in this country. That there is a desire on the part of planters to possess themselves of this manure at a cheap rate was shown by the United Planters' Association of Southern India recently petitioning Government with a view to impose an export duty on bones. The bone mea manufactured in India is remarkably pure and compares very favourably with that sold in England. The first of the two analyses quoted below is that of a genuine same of bone-dust made by Mr. F. J. Lloyd, F. C. S., of London, the second is an analysis made by Mr. D. Hooper of bones crushed at Coimbatore, Madras Presidency :—

	1	2
Water	9·90	7·30
*Organic matter	33·70	28·70
Lime	26·62	31·69
Phosphoric acid	22·50	25·53
Magnesia, salts, etc.	6·18	6·42
Silica	1·10	·36
	100	100
* Containing nitrogen	3·66	3·32
Equal to ammonia	4·44	4·03

Editor.]

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G. I. C. P. O.—No. 333 R. & A. D.—13-11-97—2,200—G. R.

PREFACE.

WITH the owner of a rusted wheat-field the question that arises is probably oftener "What can be done to prevent this loss?" that "What is the cause of this loss?" Yet to answer the first question satisfactorily, it is essential to begin by answering the second. Hence the arrangement that has been followed in digesting the information to be gleaned from the rust literature of Australia.

This treatment may strike the reader as incomplete. Besides those chapters that deal with the palliation and the avoidance of rust, why, it may be asked, is there no chapter dealing with "Rust-Eradication"? In theory, at all events, a rust should be harboured during the interval between one wheat-harvest and another on some other plant or plants. Discover such intermediate hosts, destroy them, and rust must disappear.

The omission is intentional. This method, in principle perfect, is at least in India inapplicable in practice. In the case of the majority of our Indian rusts, the intermediate hosts are unknown. In some, possibly in all, the existence of an intermediate host is not absolutely essential, other means of bridging the gap between one harvest and another having been evolved. There seems to be no doubt that in certain instances the occurrence of an intermediate host has ceased to be necessary for a rust, and there is reason to believe that the disease-germs are often practically inherent in certain wheats, intimately associated with the protoplasm of the plant and capable of continuing so for weeks or months or even years, only awaiting the advent of suitable conditions in order to dissociate themselves from the protoplasm. The partnership being thus dissolved, they may give rise to a general destructive outbreak of rust. Even in the case of that Indian rust where it seems possible that an intermediate host has been ascertained, the difficulties in the way of its eradication are so great as to render the proposal barely feasible.

Practically, therefore, the only hope for India in combatting rust in wheat is to adopt the method of selecting, from among the various kinds of wheat, those that show themselves to be naturally little liable to rust. For, while probably no wheat is absolutely immune, it is a recognised fact that in certain areas particular

wheats are relatively proof against rust. By a system of cross-breeding with kinds valuable on other accounts, new kinds can be made that will combine these qualities with the character of resistance to rust; by a further process of rigorous selection the characters of these improved kinds can be fixed under at least particular conditions and in, at all events, particular localities. If theoretically less perfect, this process is practically the sounder of the two, since it not only results in the production of wheats that resist infection from without and thus render the eradication of intermediate hosts unnecessary; it also eliminates those wheats in whose tissues the disease-germs are inherent—or, at any rate, gives us kinds wherein the fatal dissociation of the disease-germs from the protoplasm of the plant does not occur—and is thus successful in cases where the eradication of intermediate hosts must fail.

It has to be distinctly borne in mind that mere selection is rarely, if ever, sufficient. The quality of resistance to rust may be, and indeed usually is, associated with qualities that render the wheat, of which it is characteristic, otherwise undesirable. Cross-breeding, in order to associate with the resisting quality other qualities that are of importance, is, therefore, essential. The sowing of patches of this, that and another wheat and their examination during the course of a season may be useful as the basis of notes on the wheats available for experiment within particular provinces, but can do little towards a final solution of the problem before us.

This crossing of different wheats, though a *sine qua non*, is beset with many difficulties. Fortunately, however, for India these difficulties are being largely removed by the public spirit and energy of Mr. W. Farrer, of Lambrigg, New South Wales, the foremost exponent of this method of combatting rust. Mr. Farrer is placing at the disposal of the Government of India samples of crosses eminently suited for experimental culture in this country, since they combine with Indian blood—thus giving them the highest possible chance of becoming acclimatised—the blood of wheats especially characterised by the possession of the very features wherein it is known that Indian wheats are defective.

On the experts of the Agricultural Departments of the various wheat-growing provinces, therefore, devolves merely the duty of

applying to these samples the methods of selection prescribed by Mr. Farrer. But everything depends on the minute care with which these methods are applied. Mr. Farrer's recommendations, owing to their great importance, have been given in full as an Appendix (B); their perusal and adoption by those whose duty it may be to attempt to 'make' wheats that will resist the ravages of rust in India is essential. The mere sowing of Mr. Farrer's samples, in order that a record of their immunity or otherwise from rust may be recorded at the close of a season, by no means fulfils the requirements of the case. Only a small percentage of the plants raised from the first generation of Mr. Farrer's seed will supply material for further experiment; the fate of the remainder does not, therefore, interest us. The preparation of such a record implies that the object of the experiment has not been clearly understood; worse still, it may imply the waste of an opportunity and the loss of a season. To supply material whence a rust-resisting wheat may be hoped to be evolved and to receive in return no more than a barren report is to ask for bread and receive a stone.

On the other hand, it must be borne in mind that success is not to be hoped for in one season or in two; the process of evolving, of fixing, and of issuing for general use a rust-resisting wheat can only be a gradual one. Nor should it be supposed that the task of evolving a rust-resisting wheat can be completed once for all. Wheats appear to vary in character with time; wheats that prove rust-resistant and prolific in one area often fail in one or in both characters elsewhere; wheats immune as regards one rust frequently fall victims to another. This task of evolving and fixing rust-resisting wheats, once initiated, must be gone on with; continuity of policy and of effort are essential to its success. But from what may be deduced from the Australian literature here reviewed and digested, it seems not unreasonable to hope that, granted this continuity, a very decided degree of success may be attained in dealing with the rust problem.

HERBARIUM, ROYAL BOTANIC GARDEN, SIBPUR; *October 9, 1897.* — DAVID PRAIN.

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(Crop Disease and Pest Series, No. 2.)

THE

AGRICULTURAL LEDGER.

1897—No. 16.

FUNGI.

(PUCCINIA, RUST.)

RUST IN WHEAT IN THE AUSTRALIAN COLONIES.

A précis of the Literature of the Australian Inter-Colonial Wheat Conferences, 1890-96; with comments on the bearing of the results obtained on Wheat-Culture in India. *By* SURGEON-MAJOR D. PRAIN, M.A., M.B., *Curator of the Herbarium, Royal Botanic Garden, Sibpur.*

CHAPTER I.—INTRODUCTION.

Explanatory.

§ 1. The writer, by desire of the Government of India in the Revenue and Agricultural Department, has read those papers dealing with the subject of Rust, and relating mainly to Australia, that are on the files of that Department. The following pages contain a *précis* of this information with occasional comments on its bearing upon wheat-culture in India, drawn up during moments of leisure from official duties.

History of the Inter-Colonial Wheat Conferences in Australia.

§ 2. The subject of rust has caused much anxiety to Australian wheat-growers; this anxiety has been shared by the Agricultural Departments of the Governments of the various Colonies, and has culminated in the elaboration of a concerted inter-colonial scheme for counteracting the effects and mitigating the ravages of the blight. The idea of conjoint investigation and action appears to have first occurred to, or at any rate to have been first convincingly advocated by, Mr. F. Wright, a South Australian gentleman who, at a meeting in Melbourne of the Australian Association for the Advancement of Science, proposed that a Committee of the Association be appointed for the investigation of rust in wheat with a view to remedying the evil.

A Committee was appointed, but came early to recognise that, if useful results were to be obtained, the assistance of Government must be invoked. This assistance was readily granted; but the intervention of Government made the

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History of Conferences.

difficulties of working through a scattered Committee at once apparent. The idea of holding an inter-colonial conference was the natural sequel, and, in response to an invitation on the part of the Government of Victoria to the Governments of New South Wales, Queensland and South Australia to send delegates to Melbourne to meet delegates representing Victoria and discuss the Rust-problem, the "First Inter-Colonial Wheat-Rust Conference" was held at Melbourne on March 10th and 11th, 1890.

This Conference was followed by a "Second," held at Sydney on June 2nd-5th and June 8th, 1891; at this meeting the same Colonies were represented. A "Third" Conference was held at Adelaide on March 9th-12th, 1892; on this occasion Tasmania was represented in addition to the other Colonies mentioned. At the Adelaide meeting it was decided that in future the Conferences should be biennial; consequently the "Fourth" Conference, which was held at Brisbane, met in 1894 on March 20th and 21st, and March 26th-28th, while the "Fifth" Conference, which met at Melbourne, was held in May 1896.

Mode in which the results of the Conferences have been presented.

§ 3. The discussions at these Conferences mark the progress that has been made in Australia from 1890 to 1896 both as regards knowledge of Rust and as regards the best means of combatting it. The minutes of the various Conferences include, therefore, practically all that is to be learned on the subject; the somewhat numerous notes, papers, and reports that have appeared during the Conference period will be found on examination to consist for the most part of extracts from the minutes of a previous Conference or of statements of experience considered in due course at a subsequent one.

The single exception, and it is a formal rather than a material exception, consists of a series of "*Contributions to an economic knowledge of the Australian Rusts*," written by Dr. N. A. Cobb and published in the *Agricultural Gazette of New South Wales* at intervals during the period from December 1890 to April 1894. Dr. Cobb has been a delegate from New South Wales to the greater number of these Conferences, and has himself done much to make them successful. His "*Contributions*," therefore, add nothing to the sum of the information contained in the Conference minutes. They are, however, very valuable, because they treat from another standpoint, and arrange systematically, the facts that at the various conferences have been approached from the practical side and have had, of necessity, to be dealt with on empirical lines.

Literature reviewed.

§ 4. The literature here reviewed and digested may, therefore, be classified as :—

I.—Conference Literature; Reports of the various Australian Inter-Colonial Wheat-Rust Conferences.

II.—Inter-Conference Literature; Reports, Bulletins and Papers dealing with points referred to at a previous Conference or suggested for discussion at a subsequent one.

III.—Extra-Conference Literature; Dr. Cobb's "*Contributions*" published by the Government of New South Wales in its *Agricultural Gazette* during 1890—94.

To facilitate reference to the originals, a full list of the papers, classified in this way, is here given and, in subsequent chapters, papers of the various groups are referred to, shortly, as (I.) I Conf., II Conf., etc.; (II.) Sub-conf. A., B., C., and so on; (III.) Cobb. Contrib., the volume and page cited in the latter case being those of the New South Wales *Agricultural Gazette*.

§ 5. I.—CONFERENCE LITERATURE.

Reports of Australian Inter-Colonial Wheat-Rust Conferences.

1. Minutes of Proceedings at a Conference of delegates from Victoria, South Australia, New South Wales, and Queensland; held at Melbourne, March 10-11, 1890: *ref.* I Conf.
2. Report of the Proceedings of the Conference of delegates from Victoria, South Australia, New South Wales and Queensland; held at Sydney, June 2-5, and June 8, 1891: *ref.* II Conf.
3. Report of the Proceedings of the Conference of delegates from Victoria, South Australia, New South Wales, Queensland, and Tasmania; held at Adelaide, March 9-12, 1892: *ref.* III Conf.
4. Report of the Proceedings of the Conference of delegates from Victoria, South Australia, New South Wales, and Queensland; held at Brisbane, March 20, 21, and March 26-28, 1894: *ref.* IV Conf.

5. Final Report of Committee at the Conference of delegates held at Melbourne, May 1896: *ref.* V CONF.

In order that a brief, yet clear, view may be had of what has been accomplished at *each* Conference, the Reports of the various Conferences in Committee are given in full as Appendix C.

§ 6. II.—INTER-CONFERENCE LITERATURE.

NEW SOUTH WALES.

A. 1891. Agricultural Gazette of New South Wales, vol. 2, part 7, page 403 (July 1891)—
Rust on Wheat Conference (second) *held at Sydney.*

B. 1892. Agricultural Gazette of New South Wales, vol. 3, part 3, page 221 (March 1892)—
Recommendations of the Conference (third) *held at Adelaide.*

C. 1892. Agricultural Gazette of New South Wales, vol. 3, part 7, page 481 (July 1892)—
Further References to the Recommendations of the Rust in Wheat Conference held at Adelaide in March 1892.

D. 1892. Agricultural Gazette of New South Wales, vol. 3, part 8, page 567 (August 1892)—
Rust-resisting Wheats.

E. 1893. Agricultural Gazette of New South Wales, vol. 4, part 7, page 598 (July 1893)—
Rust-resisting Wheats.

F. 1894. Agricultural Gazette of New South Wales, vol. 5, part 1, page 48 (January 1894)—
Rust-resisting Wheats.

G. 1895. Report regarding the working of Department of Agriculture, New South Wales, January 1894—July 1895, pages 25-28—
Experiments with Wheats.—Dr. Cobb.

H. 1897. Letter from W. Farrer, Esq., Lambrigg, Queanbeyan, N. S. W., to the Government of India, Department of Revenue and Agriculture (August 1897)—
Wheats likely to prove suitable for the Climate of India.

TASMANIA.

I. 1892. Department of Agriculture, Tasmania; Bulletin n. 3—
On Rust in Wheat.—E. H. Thompson.

QUEENSLAND.

J. 1892. Department of Agriculture, Queensland; Bulletin n. 19—
On Wheat-growing in Queensland.—E. M. Shelton.

K. 1895. Department of Agriculture, Queensland; Bulletin n. 6 (second series)—
On Wheat-growing Experiments.—E. M. Shelton.

VICTORIA.

L. 1894. Department of Agriculture, Victoria—
Report on Wheat-Rust Experiments, 1892-93.—D. McAlpine.

NEW ZEALAND.

M. 1894. Second Report of Department of Agriculture, New Zealand, page 53—
Rust.

N. 1894. New Zealand Country Journal, vol. 18, No. 3, page 220—
Rust in Wheat.

O. 1895. New Zealand Country Journal, vol. 19, No. 5, page 493—
Experiments with Rust-preventing Manure at Lincoln College.

SOUTH AUSTRALIA.

P. 1896. Copy of Minute by the Secretary to the Agricultural Bureau, South Australia, dated Adelaide, May 8, 1896.

CANADA.

Q. 1896. Report on Wheat-Rust by the Director of the Experimental Farm in Canada.

Ref. SUB-CONF. A., B., etc. Owing to the fact that some of these notices are digests of Conference proceedings (*e.g.*, A. and N.) or *verbatim* extracts from Conference minutes (*e.g.*, B.); while still others (*e.g.*, D., E., F.) consist of information incorporated in the minutes of subsequent Conferences, it has not been necessary in every case to formally cite these papers in the chapters that follow.

Three Indian papers:—*Resolution on the Revenue Administration of the Central Provinces for the year* 1894-95; *Indian Fungi* (Agricultural Ledger, 1895, No. 20); and a *Report by the Commissioner of Settlements and Agriculture, Central Provinces, on the Cultivation of Cross-bred Wheat,* 1897; which the writer has likewise been directed to read in connection with this subject, belong in a fashion to this list; it has, however, seemed more convenient to keep them apart from the Colonial literature and to quote them separately.

§ 7. III.—EXTRA-CONFERENCE LITERATURE.

Contributions to an economic knowledge of the Australian

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Literature of Conferences.

Rusts. *By* N. A. Cobb. Published in the *Agricultural Gazette of New South Wales* in the following order :—

	Vol.	Part.	Page.	Date of Publication.
Introduction	1	3	185	Dec. 1890.
Chapter I.—Methods . . .	,,	,,	186	,, ,,
Chapter II.—Rusts that occur in and about Australian wheat-paddocks	1	3	197	,, ,,
Appendix A.—Details of experiments, etc., undertaken in order to learn what rusts occur in and around the wheat-paddocks in New South Wales . . .	,,	,,	203	,, ,,
Resumé . . .	,,	,,	214	,, ,,
Chapter III.—What has been found out in this and other countries concerning wheat-rust . .	3	1	44	Jan. 1892.
Chapter IV.—The subject continued	,,	,,	52	,, ,,
Appendix B.—Report on the rustiness of wheats examined at Lambrigg	,,	,,	60	,, ,,
Alphabetical List of wheats examined at Lambrigg .	,,	,,	60	,, ,,
Chapter V.—The subject continued	,,	3	181	Mar. 1892.
Chapter VI.—An examination into the physical properties of Rust-Resistant and Non-Rust-Resistant wheats	,,	,,	190	,, ,,
Appendix C.—Measurements of the thickness of leaf (flag) in different varieties of wheat .	3	3	201	,, ,,
Appendix D.—Width of penultimate leaf at the middle . .	,,	,,	206	,, ,,
Appendix E.—Measurements of the tensile strength of the penultimate leaf of different varieties of wheat	,,	,,	207	,, ,,
Chapter VI (*bis*).—Varieties of wheat	4	6	431	June 1893.
Chapter VII.—Keeping seed-wheat true to name. Causes leading to mixed seed . .	,,	7	503	July 1893.
Chapter VIII.—The artificial cross-fertilizing of wheat . .	,,	,,	506	,, ,,
Chapter IX.—Improving wheats by Selection. Experimental plots .	,,	,,	512	,, ,,
Chapter X.—The subject continued	5	4	239	Apl. 1894.
Chapter XI.—Harvesting experimental wheats . . .	,,	,,	251	,, ,,

F. 725.

It will be observed that two distinct "Contributions" are marked "Chapter VI." *Ref.* COBB. CONTRIB. with vol. and page of *Gazette*.

To this class belong the majority of the European and American treatises and pamphlets that have been consulted in drawing up CHAPTER II; here again it has been more convenient to keep them apart from the Australian literature and, when necessary, to quote them separately.

CHAPTER II.—THE RUST-PROBLEM.

Damage from Rust.

§ 8. Addressing the delegates to the first Inter-Colonial Conference on Wheat-Rust in 1891, the Minister of Agriculture for Victoria put the loss from rust for the previous season at £1,500,000 sterling for South Australia alone, and appeared to think the loss in Victoria had been as great (I. CONF., p. 6).

The same season, evidently one in which Rust was particularly destructive, is independently calculated to have caused a loss of £2,370,000 sterling in Australia generally, and of about £30,000 in Tasmania (SUB-CONF. I. 8).

The Committee appointed to draw up a series of Resolutions at the First Conference gave the estimated loss at £1,500,000 for South Australia, £750,000 for Victoria, £100,000 for New South Wales, £20,000 for Queensland. The total loss suffered was estimated at not far short of £2,500,000 sterling (II. CONF., p. 41).

In the Gippsland province of Victoria where, 35 years before, wheat was widely grown, it was stated in 1891 that its cultivation had for 30 years been largely abandoned owing to the ravages of rust (II. CONF., p. 13). As an instance of the losses caused by Rust, may be cited the experience of a South Australian gentleman. On one plot of 5,000 acres, farmed on metayage,—owner finding land and seed and taking $\frac{2}{5}$ths the produce, metayer finding labour and taking $\frac{3}{5}$ths,—the share of the former was estimated in October to be worth £5,000. The wheat was attacked by rust in November and yielded the owner nothing.

The loss in Victoria in 1889 ranged from 2 bushels and 10*s*. per acre to 20 bushels and £5 per acre (II. CONF., p. 16).

The Minister for Mines and Agriculture in New South Wales, addressing the delegates at the Second Conference, stated that, if only one or two bushels per acre of the wheat now destroyed by rust were saved to Australia, it would mean an addition of £100,000 annually to the national wealth.

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Anything *short* of eradication of rust must therefore still be of the greatest advantage (II. CONF., p. 2).

The sum mentioned must be an error of the printer for £1,000,000 or some similar figure. For if the average loss in South Australia be, as is stated (II. CONF., p. 50), 7—8 bushels per acre in rusty years, and if the rates quoted for Victoria are in any way applicable to the other Colonies, the gain in South Australia alone would be several millions sterling, since in 1892 the Minister of Agriculture and Education for South Australia was able to inform the delegates to the Third Conference that in 1891 there were 3,147,106 acres under wheat in the whole Colony. This was, moreover, the area actually reaped and did not include what, owing to its having been attacked by rust, was cut for hay (III. CONF., p. 9).

The Rust-disease is the only serious obstacle to the cultivation of wheat in Queensland. In 1889, of 15,861 acres only 2,700 acres were rust-free. The average yield per acre in rust-affected areas was 17 bushels, in rust-free areas 21 bushels. But these figures show only a small part of the total damage done, for no more than 7,504 acres were reaped as wheat; 7,326 acres,—or nearly half the total acreage—had to be reaped as hay so soon as the rust appeared (II. CONF., p. 29).

In New South Wales in 1891 the average loss per acre was a little over 2 bushels per acre: the total loss was 636,520 bushels (III. CONF., p. 13). In Victoria in 1891 only 109 acres had to be cut for hay, but in North Victoria the loss varied from 2-12 bushels per acre, in South Victoria from 2-10 bushels per acre (II. CONF., p. 18).

For India it is estimated that an annual loss of 10 per cent. is under rather than over the mark (*Agric. Ledger*, 1895, n. 20, p. 72).

Rusty Years.

§ 9. It is believed in Chili that the conditions which favour the appearance of rust recur regularly once in seven years (II. CONF. 47). In Australia a similar belief in a cycle of eleven years is indicated (II. CONF. 15).

Rust in Australia is undoubtedly much more prevalent in certain seasons than in others. These do not, however, display any periodicity, nor are they always common to the several Colonies. It is the general experience of Australian farmers that rust, in amount sufficient to do serious harm, does not often appear in two succeeding years (II. CONF. 15).

In South Australia rust has been known since 1851 and at short intervals has caused much loss (II. CONF. 50).

The year 1860 is mentioned as one in which the wheat crop was a total failure in New South Wales, whereas no mention is made of rust that year in Victoria. The years 1863 and 1864 are given as rusty years in Victoria, though, as a matter of fact, rust has been recorded for that Colony every year from 1862 onwards (II. CONF. 15). In 1867 it was almost general and caused immense loss in South Australia (II. CONF. 50). In 1875 there was much rust in Tasmania (II CONF. 23); 1878 was one of the worst years for rust in Victoria (II. CONF. 15), and in South Australia (II. CONF. 50) it prevailed over a considerable area that year. In South Australia 1880 was another year when a considerable area was affected. The seasons 1882—1888 seem to have been very free from rust, but 1889 was a year in which it was almost general and caused great loss in South Australia (II. CONF. 50), in Victoria (II. CONF. 15), in New South Wales (II. CONF. 32), and in Tasmania (III. CONF. 23). In 1890 it was again almost general throughout South Australia (II. CONF. 50); the year was not considered a "rusty" year in Victoria. In 1893-94 rust was prevalent in many parts of Wellington, N. Z. (SUB-CONF. M. 53).

The experiences of 1867, 1878, and 1889 favour the theory of a cycle of eleven years (II. CONF. 15), but the facts against it are quite as weighty. [In any case the periodicity, supposing it to exist at all, is not due to any inherent property of rust, but must, as seems to be the belief in Chili, be the result of a recurrence of conditions favourable for its development.]

The Indian experience is parallel with the Australian.

Annoyance caused by Handling Rusted Wheat.

§ 10. An incidental effect of rust is the annoyance that is said to be caused by handling rusted wheat. It appears that on Darling Downs (Queensland) it is hard to obtain help to work wheat affected by rust. The men are said to develop large ulcers and sores, caused by working among rusty wheat (II. CONF. 38). In Victoria too there is said to be no doubt that the threshing of rusty wheat has caused ulcers among the men (II. CONF. 39).

There seems to be no reference to any such experience in India.

Natural History of Rust.

§ 11. Rust in wheat is due to the parasitic existence on the wheat plant of a fungus (*Puccinia*), which is normally of a polymorphous and of a heterœcious nature.

Both characters vary in extent in different *Pucciniæ*, but, as regards the better-known rusts affecting wheat, they

are limited as follows. The rusted wheat, when examined closely, is seen to derive its "rusty" appearance from the presence of red or brown pustules (*sori*) scattered over the flag, or at times also affecting the straw or even the ears. These vary in size from $\frac{1}{25}$ - $\frac{1}{5}$ of an inch long by $\frac{1}{75}$ of an inch wide, and in the majority of the wheat-rusts increase in size, so that the cuticle of the plant, which at first is continuous throughout, at length gives way over the site of each pustule.

The variation in size and shape is due to a tendency the pustules at times show to run together; this tendency is naturally influenced by the severity of the disease—which is in turn affected by the favourable or unfavourable character of the conditions in which the wheat grows; also, by the character of the tissues of the plant—which depends upon the variety of wheat, the age of the plant, and the part affected.

The contents of a rust-pustule, when closely examined, are found to be masses of minute red or brownish single-chambered oval bodies (*spores*) supported by fine transparent stalklets that in turn spring from an interlacing network of pellucid threadlets (*mycelium*) ramifying in the tissues of the plant. These ramifying fibres really constitute the parasite that lives upon the food-material elaborated by the wheat-plant for its own use; it is the appropriation of this elaborated matter by the fungus that starves the wheat-plant and leads to the "pinching" or total absence at the end of the season of the grain that this food-material would otherwise have gone to form. Once such a fibrous mycelium obtains a footing within a wheat-plant, it goes on growing till it forms a pustule, the spores inside which are bodies specially modified to assist in the perpetuation and reproduction of the fungus. When the pustule is ripe, the spores are shed as a small cloud of microscopic red dust. When the spores are carried to the leaves of still unaffected plants and the conditions as to warmth and moisture are suitable, the membrane enclosing each gives way at certain definite weaker points and the contents exude as a narrow thread-like stream that extends across the surface of the leaf on which it rests till its free end finds one of the breathing-pores (*stomata*) with which the surface of the leaf is studded. The thread now grows in through this *stoma;* once inside, it proceeds to absorb the nutrient juices of the plant, to grow vigorously and ramify in all directions, so producing a mycelium that goes on to the formation of pustules and spores as before. This stage of growth of the fungus is the *Uredo* stage, these red spores are termed *uredo*-

spores, and it is the phase of growth which is manifested by their production that is popularly known as *Rust.*

So long as the weather conditions are suitable and the wheat-plant holds out as a source of food, the fungus is believed to go on producing successive crops of rust-pustules and spores. But towards the end of summer a change usually takes place in the development of the fungus, and among the red pustules which rupture to let the spores escape, black ones, over which the cuticle of the plant often remains intact, begin to make their appearance. The presence of these black pustules gives rise to the naked-eye appearance of dark-grey to light-grey streaks on account of which this stage of the growth of the fungus is known popularly as *wheat-mildew.* The contents of a mildew-pustule are spores as before, but spores of a different kind. Instead of being one-celled, each is double, being divided across the middle; instead of germinating rapidly if, and perishing readily unless, they encounter suitable conditions, these black spores, as a rule, require to rest through the remainder of autumn and during the winter, and cannot germinate till the following spring. As they need this period of rest, and because they complete the growth of the fungus for the season, they are termed variously *resting spores,* or *teleutospores* (ending-spores). This mildew stage being, after a fashion, a concluding one, constitutes the *Puccinia* proper.

At the commencement of the following season these teleutospores germinate by the protrusion of their contents through a weak spot in the membrane just as happens with the uredospores. The subsequent growth and history is, however, different in the two cases. Instead of endeavouring to find its way within the tissues of some other plant, the thread remains exposed, branches but slightly, and at the tips of the branches it forms, simply by spontaneous separation (abjointing) and not by special formation of true spores, minute spore-like bodies that are carried away by the wind to germinate under favourable conditions on, and to penetrate and live parasitically within, the tissues of some other plant. The branching thread that issues from the teleutospore resembles, but still does not really constitute, a true mycelium; it is therefore termed a *pro-mycelium*, and the small bodies that behave like, though they differ in formation and structure from, true spores are termed *sporidia.*

On whatever plant these sporidia rest and germinate they give rise to a mycelium, the presence of which, in the majority of instances, causes swellings, generally of some fairly

bright colour, to appear in the tissues of the leaf of the host-plant. Embedded in this swelling are usually small cup-like bodies of different sizes; the smaller, termed *spermogonia*, contain cells termed *spermatia*, the object and nature of which are not precisely known; the larger, termed *æcidia*, contain yellow spores termed *æcidiospores* which are known to produce, in some cases at least, when they germinate under suitable conditions, a mycelium that produces rust-pustules of *uredospores*.

There are thus two stages, and four very distinct phases in the life of a fully developed *Puccinia* from teleutospore to teleutospore.

The first phase is the production of the *pro-mycelium* with the separation of its *sporidia*. This promycelial phase is characterised by being non-parasitic. The germination of its *sporidia* gives rise to a parasitic mycelium that produces the second or *æcidial* phase, which ends in the formation of special spores (*æcidiospores*). The production of these æcidiospores ends the æcidial stage of the life-history of the fungus, because the germination of these gives rise to a parasitic mycelium that produces throughout its existence successive crops of rust-pustules containing uredospores, and ends in the formation of resting-spores or teleutospores. The formation of these teleutospores ends the *puccinial* stage of the existence of the fungus; the two phases of this stage, the *uredosporic* and the *teleutosporic*, though practically successive, are organically simultaneous, since they are produced by the same mycelium, and thus differ from the two phases of the æcidial stage which are organically as well as chronologically successive.

There are two well-marked classes of *Puccinia*, those that are "autœcious" or that spend the *Puccinia* stage and the parasitic phase of the *æcidial* stage on the same host plant; and those that are "heterœcious," and find it necessary that the two different mycelial stages shall live on and be nourished by different host-plants. The arrangement that ensures this result is exceedingly simple. In the first class the *sporidia* produced during the non-parasitic pro-mycelial phase are capable of germinating on the plant which carried the teleutospore that gave rise to the pro-mycelium. In the second class these sporidia cannot germinate on the plant that carried the teleutospores, but are only able to do so on some quite different species. Looking then at the formation of teleutospores as completing the round of existence of the fungus, and treating the formation of a pro-mycelium, with its resulting sporidia, by the germination of these teleutospores as the com-

mencement of a new round, we speak of the plant which carries the *Puccinia*,—that being differentiated by the characters of its teleutospores,—as a "host" of the fungus; in the case of a member of the second or "heterœcious" class, where the æcidial stage exists on a plant other than the one that carries the *Puccinia*, we speak of the plant on which the *æcidium* exists as an "intermediate host" of the fungus.

A characteristic feature of most, if not all, *Pucciniæ* is that they are restricted as to their habitat; a particular *Puccinia* is only met with on a particular host in the case of the autœcious ones and both the host and the intermediate host, which *must* themselves be different plants, may be equally particularised in the case of the heterœcious ones. It is, however, not usual, particularly in the case of the better known *Pucciniæ*, to find that either the *æcidial* or the *Puccinia* stage, even in the heterœcious class, is strictly limited to any one special plant; usually the fungus is to be found on a smaller or greater number of naturally closely allied plants; these then are "collateral" hosts. Sometimes indeed the same stage may occur on widely different plants; in such cases it is perhaps usual to find that one or other of these is affected by only one phase of that stage.

Finally, it must not be overlooked that both stages are not in all cases known; it seems, indeed, likely that the two are not in every case necessary. Thus *Æcidia* are known and described, the corresponding *Pucciniæ* of which are at least as yet undiscovered. There seems reason to suspect that in some of these cases the *Puccinia* has disappeared, and that the æcidial stage has come to be able to perpetuate itself directly. This stage is not, however, in any case a cereal blight, and the matter does not therefore directly concern us. What is of practical moment is the fact that the æcidial stage of certain *Pucciniæ* is unknown; perhaps even is non-existent, either from never having been evolved or from having become unnecessary. Hypothetically there are three possible explanations of the absence of the æcidial stage of a *Puccinia* :—

(1) Perhaps it does occur but has not yet been discovered. Possibly this is even true of many cases where there is direct evidence that the stage is not absolutely essential.

(2) A frequently advocated theory is that the *sporidia* produced by the pro-mycelia to which the germinating teleutospores give rise, while retaining the power of developing on the "intermediate host"

into a mycelium which produces æcidia, acquire also the power of developing on the "host" into a mycelium which produces uredospores and teleutospores (CONF. I., 51; SUB-CONF. L. 29). This hypothesis has never been confirmed by any competent observer.

(3) The third explanation is that the blight can dispense in certain cases, and at least for a time, with its æcidial stage owing to the resting phase (*teleutospores*) of the *Puccinia* stage never requiring to come into play, the active phase (*uredospores*) of this *Puccinia* stage being able in these cases to produce successive crops throughout the year. The "collateral" hosts of the *Puccinia* are not necessarily contemporaneous species; one may be coming into vigorous growth as another is dying down. Oftener still, while one may, like a cereal crop, be annual, and thus on being reaped cease for a period of months to be a possible host for the blight, another in all likelihood is some perennial grass on which the blight may exist and may form successive crops of uredospores during the interval between the cereal crops of two succeeding seasons. This, too, may happen without the collateral host in question being seriously inconvenienced; a "rust" that under certain conditions is almost fatal to a particular crop, may be present on another plant without doing it, even under the same conditions, any great harm. This hypothesis is hardly more satisfactory than the preceding one. Far from spreading freely from one collateral host to another, the same rust invariably shows the utmost disinclination to pass even from one race to another of the same collateral host. This has been shown by careful experiment in America (*Kansas Expt. Station*, Bull. n. 46, p. 4) and in Europe (APPEND. A., p. 71).

Rust in Europe.

§ 12. Rust to the farmer is more or less of a simple entity, and is supposed by him in Britain to consist at most of but two sorts, the spring and the summer rusts respectively, the former appearing in the period from March to May and doing little damage as compared with the latter, which does not usually appear till June or July. The experience of the continent appears to be somewhat the reverse; there the earlier or spring rust seems to be, as a rule, the more harmful.

The opinion of the practical agriculturist has carried perhaps a little too much weight with the botanical student for, though it has been fairly apparent that there are really more than two forms of rust affecting the cereal crops in Europe, these forms have been all set down as particular manifestations or conditions, at very outside as mere varieties of one or other of these two. The spring-rust has been identified, as a rule, with *Puccinia rubigo-vera*, a species of which the hosts were supposed to be Rye and Wheat and a number of wild grasses, while the intermediate hosts were said to be certain Borages (a couple of Alkanets and a Bugloss). The summer-rust has been identified with *Puccinia graminis*, a species the hosts of which are a crowd of wild grasses and all the common cereals, the intermediate hosts being a number of species of Barberry. Besides the "Wheat-Barberry" and the "Wheat-Borage" rust there was, however, admittedly a "Wheat-Buckthorn" rust, *Puccinia coronata*, with its hosts, as before, a number of grasses and its intermediate hosts several of the Buckthorns.

In America this "Wheat-Buckthorn" rust appears to be a subject that calls for serious practical consideration. In Australia it is not known to occur at all; in Asia and in Europe it does not occur on wheat. That attention should have been mainly confined in Europe to the other two was not therefore unreasonable.

The treatment they have received has not, however, been altogether accurate. Practically the natural limits of "Summer" or "Wheat-Barberry" rust have been found to agree with the *Puccinia graminis* of botanical works, though it appears that a quite distinct rust, which occurs only on "Timothy-grass" and does not affect wheat, has been confused with it. The "Yellow Spring" rust has, however, been much confused. Practically the typical form has been naturally enough defined in books, so far as the *Uredo-Puccinia* stage is concerned. But it is found that the idea that the *æcidial* stage of "Yellow Spring" rust occurs on any "Borage" is erroneous. The æcidial stage and the intermediate host of the common "Yellow Spring" rust are unknown, and the æcidium referred to as occurring on the two Alkanets belongs to a quite different rust, the "Brown" rust. Under the name of *Puccinia rubigo-vera* or "Spring" rust, two different rusts have thus been included, *viz.*:—

(1) "Yellow" Rust (*Puccinia glumarum*) of which the intermediate host and the *æcidium* have not been found or do not exist, and

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(2) "Brown" Rust (*Puccinia dispersa*) which is alone entitled to be termed the "Wheat-Borage" rust, since it has an *æcidium* that occurs on various Borages. At the same time the *Puccinia* usually referred to in books as a variety (VAR. *simplex*) of *Puccinia rubigo-vera*, turns out to be quite distinct from "Yellow" and from "Brown" rust alike. As in the case of "Yellow" rust, its æcidial stage and its intermediate host or hosts are unknown.

In the most exhaustive work on European Rusts, *Die Getreideroste*—by Messrs. Eriksson and Henning, who have for several years been engaged in studying practically the subject of rust on behalf of the Government of Sweden—an enumeration of these rusts and of their hosts is given. The following are the salient facts in this list:—

1. PUCCINIA GRAMINIS, or BLACK RUST, occurs, in Scandinavia alone, in its *æcidial* stage on 5 species of Barberry and in the *Uredo-Puccinia* stage on 107 different grasses including OATS, BARLEY, RYE and WHEAT, and under wheat, on common wheat, hard wheat and 'spelt' alike. Outside Scandinavia the *æcidial* stage has been found on 8 other species of Barberry and the *Uredo-Puccinia* stage on 43 other grasses.

There are thus no fewer than 150 known collateral hosts for the Black-rust and 13 collateral intermediate hosts for its æcidial stage. That these figures are not exhaustive is very probable seeing that in other countries the search for it has not hitherto been so systematic as that instituted in Sweden. That this particular rust spreads as *Uredo* on cereal crops by reason of its being harboured by Barberry bushes in the *æcidial* stage has been repeatedly demonstrated. But that the passage through this æcidial stage is only occasionally, if indeed it ever be, essential is equally evident since outbreaks of rust have over and over occurred where it was impossible to trace the attack to the presence of the æcidium on Barberry bushes, or indeed to find any Barberry bushes that could harbour the æcidium. In other places, too, the complete eradication of Barberries, which in theory ought to have exterminated the blight, has in practice failed to do so. Yet, in spite of the extraordinary number of grasses that harbour the blight in the stage which is harmful to cereals, and enables it to tide over the interval between two cereal crops on one or other of its collateral hosts, as von Tubeuf and others have again and again found that it actually does, it is remark-

able that it does not make use of its opportunities. On the contrary, the forms of the rust affecting the four cereal crops are as distinct physiologically as if they were different species (APPEND. A., p. 70).

The most important observation from the Indian point of view that has been made in Europe, is that *Puccinia graminis* occurs on RICE in Italy. It is not said sensibly to affect the rice crop, but if it exists on rice at all, it would be quite easy to account for the existence of this particular rust in India throughout the year without any change of host or of stage being called for. But, as will be shown presently, the Rust which in India is taken to be *Puccinia graminis* may not be that species, and in any case the probabilities are against the *immediate* infection of the one crop by the other.

2. PUCCINIA PHLEI-PRATENSIS, or "TIMOTHY-GRASS" RUST, which Eriksson and Henning separate off from 'Black Rust,' occurs only on Timothy-grass (*Phleum pratense*) in the *Uredo-puccinia* stage, and, so far as is known, affects no cereal crop. Its æcidial stage is unknown and is perhaps non-existent.

3. PUCCINIA GLUMARUM, or "YELLOW" RUST, is the next important rust that is dealt with by Eriksson and Henning. Its æcidial stage is quite unknown and is perhaps non-existent. In Sweden the *Uredo-Puccinia* stage has been found on 15 grasses, including RYE and WHEAT, under the latter on common, hard and 'spelt' alike. It has not been met with on barley. Outside Sweden it has been met with, for certain, on one other grass; and assuming, from the descriptions and measurements given, that certain (perhaps the majority) of the cases of occurrence of *Puccinia rubigo-vera* refer really to *P. glumarum*, Eriksson and Henning conclude that it is borne by 38 other grasses, including OATS. There are thus probably 54 collateral hosts of this *Puccinia*.

The *P. rubigo-vera* of Australian writers is, according to Eriksson and Henning, this species. They do not, however, suggest that the so-called *P. rubigo-vera* of Indian authors is to be referred here, and in this, as will be seen presently, they are probably quite justified.

4. PUCCINIA DISPERSA, OR "BROWN" RUST, is the third important rust that Eriksson and Henning give.

This occurs in Sweden in the *æcidial* stage on two of the Alkanets and in the *Uredo-Puccinia* stage on 11 grasses, including RYE and WHEAT, both common wheat and 'spelt.'

This is the true 'Wheat-Borage' Rust of Sweden and probably is the 'Wheat-Borage' Rust of other countries also. As

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yet, however, no list of collateral hosts is available beyond the limits of Sweden. There is no evidence that this rust occurs at all in Australia, and there is every reason for believing that it does not occur in India (*Agric. Ledg.*, 1895, n. 20, p. 46).

5. PUCCINIA SIMPLEX, or "PIGMY" RUST, another rust enumerated, is not very important. Its *æcidial* stage and intermediate host, if it has such, are not yet known, and as an *Uredo-Puccinia* it only occurs on Barley.

This has often been treated as a mere variety of '*P. rubigo-vera,*' but it seems to be quite distinct, and in any case when one considers that *P. rubigo-vera* has hitherto been a confused entity, it is better kept apart.

There is no evidence that this occurs in Australia, and an Indian rust which Dr. Cunningham and the writer have suggested the necessity for comparing with this one (*Rec. Bot. Surv. Ind.* I., 121) turns out, now that an accurate account of *P. simplex* is available, to be quite different.

6. PUCCINIA CORONATA, or "CROWN" RUST, is the last rust described in Eriksson and Henning's work. This occurs in Sweden in the *æcidial* stage on three species of Buckthorn and in the *Uredo-Puccinia* stage on seven different grasses, one of these being OATS. Outside Sweden its *æcidium* has been found on nine other Buckthorns (one of these being an Indian one) as well as on a *Berchemia*, a plant very closely allied to the Buckthorns. Its *Uredo-Puccinia* stage, outside Sweden, has been found on 42 different grasses, including BARLEY (both in Europe and America); RYE and WHEAT (on the last two in America only, so far as is hitherto known).

This *Puccinia* has thus 49 known collateral hosts, and of these four are Indian, with 13 collateral intermediate hosts.

But though it attacks most, if not all, the common cereal crops in America, it has in Europe, outside Sweden, only been found on BARLEY, there apparently doing no serious harm. In Asia it has not been found to attack our cereal crops, and in Australia it is apparently unknown.

Rust in Australia.

§ 13. As regards Australia, we find that in 1890 Dr. Cobb examined 124 specimens gathered from different parts of New South Wales. Of these, 6 were the rust identified in Australia with *Puccinia graminis*, 2 were *Puccinia poarum*, 102 were the "*Puccinia rubigo-vera*" of Australian writers, and 4 belonged to an undetermined species of *Puccinia*; the remaining 10 were miscellaneous.

Puccinia poarum was found on "Meadow grass" (*Poa annua*) only; of the examples of "*P. graminis*" one was on

wild oats, two were on oats, one on Barley and two on Wheat.

Of the "*Puccinia rubigo-vera*" examined, 94 were on wheat, two on oats, four on barley, one on rye-grass. Of the undetermined *Puccinia*, one was on wheat, two were on a native grass (*Deyeuxia Forsterii*), and one was on *Bromus mollis* (an introduced grass).

Considering wheat alone; of 97 rusted wheats, 94 were attacked by *Puccinia rubigo-vera*, two by *P. graminis*, and one by the undetermined species. The conclusion arrived at, therefore, is that Australian wheats are subject to three rusts, and that of these three the rust which did practically all the damage in 1890, was the rust identified as *Puccinia rubigo-vera*. But Dr. Cobb expressly points out that his investigations refer only to one season and only to that part of it up to November 6. He does not conclude that the results for another season need be the same (COBB, CONTRIB., vol. I., p. 214).

At the Second Conference also Dr. Cobb expressed his opinion that it is their "Spring-rust" (the supposed *Puccinia rubigo-vera*) that did most damage in New South Wales. It was supposed that in 1889 the destructive rust which attacked oats, barley, rye and some other grasses, besides wheat, was "Summer-Rust" (*P. graminis*), since the rust appeared in long lines, not in spots; in ordinary seasons (as in 1890) it is "spring-rust" that does most harm. This rust affects chiefly the flag, less often the straw (II. CONF. 34). It may be found all the year round on self-sown wheat, oats, or barley, and on certain wild grasses, and can pass from these to the wheat crop, the *uredo*-stage being continuous throughout the year whether the rust be "spring-rust" or "summer rust" (II. CONF. 37, 50; III. CONF. 29). The spores, moreover, may be twenty days in water and yet not lose their germinating power, so that they may exist occasionally in the soil for sufficient time to bridge over accidental gaps in the chain of collateral hosts (II. CONF. 34). Mr. McAlpine, however, states that he had failed up to 1891 to find any of the grasses mentioned as collateral hosts affected by either of the wheat-rusts (II. CONF. 16).

If "summer-rust" were the most destructive rust, then early sowing would be a great remedy since the wheat would be ripe ere the rust appeared. At the same time, Dr. Cobb advocates early sowing in spite of the apparent suggestion of a doubt as to its efficacy (II. CONF. 35).

Mr. McAlpine's experience in Victoria is that it is the

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summer rust (*P. graminis*) that is most injurious (SUB-CONF. L. 27); of 36 varieties of wheat examined by him, only one was free from rust and only one was affected by *P. rubigo-vera*; all the others were attacked by *P. graminis* (III. CONF. 68). It is, however, fairly certain that in nearly all the years characterised as rusty, early-sown wheat has suffered badly from rust (IV. CONF. 20), an experience that certainly indirectly favours Dr. Cobb's judgment. But Mr. Farrer thinks the fact that most of the wheats said to be "rust-proof" nevertheless suffer badly from "*Puccinia rubigo-vera*" and are more or less resistant only to *P. graminis*, is important as involving popular recognition of the truth that *P. graminis* does most damage in Australia (III. CONF. 36; SUB-CONF. H. 4). And when the early rust ("*P. rubigo-vera*") is apparently very bad, it is not really that which does the harm; it passes off, but *P. graminis*, which comes on later, destroys the crop.

In dealing with this aspect of the question Mr. Farrer objected to the seasonal distinction of name between these two rusts as not quite appropriate for Australia, or at all events for New South Wales. Mr. Farrer proposed the names "spotted-rust" for the earlier, and "streaky-rust" for the later, owing to the pustules being scattered in the former, and often confluent in the latter. His proposal did not, however, meet with approval, because "spottiness" and "streakiness" were not considered characteristic of the rusts by the other delegates. One Victoria delegate disliked the idea of any change of name. However, the President of the Third Conference at Adelaide pointed out that the term "summer-rust" in particular is not a good name in South Australia owing to the seasonal peculiarities of the Colony. Mr. McAlpine (Victoria), who objected to Mr. Farrer's names because streaky-rust is always spotted in its early stages and so might be mistaken for the other, prefers to term the spring or spotting or small rust the "yellow" rust, and the streaky or summer or common rust the "orange-red" rust. These are, no doubt, better names.

It is with the latter,—which Mr. McAlpine says is known everywhere to botanists as *P. graminis*,—that the farmer has mainly to deal. The former, which is known as "*P. rubigo-vera*," though claimed as commonest in New South Wales, is not so in Victoria, any more than Plowright has found it to be in England or than Galloway has found it in the United States (SUB-CONF. L, 27; II. CONF. 17). Dr. Cobb, however, who at most only pointed out that this rust was the commoner in New South Wales during the early part of 1890,

says that both are destructive to wheat in Australia (III. CONF. 29); doubtless this is the true state of affairs.

At the Second Conference one delegate, quoting from a South Australian report, said it had been noticed that in some localities red-rust appeared before the humid weather of September and October; in other localities, towards the south-east, after the dry hot weather had set in. The earlier rust is known popularly as "long-corn" rust and appears to have borne its full share with the "true" rust in destroying the harvest (II. CONF. 48). In this report the later rust is termed "vera rubigo," evidently from some confusion of thought as regards the name of one of the rust-fungi. The particular fungus thought of—*P. rubigo-vera*—is, however, an early, not a late, "rust." Fortunately the name, which is thus shown to be capable of misleading, does not any longer require to be used. The "yellow" and the "orange-red" rusts, according to McAlpine, both produce *teleutospores* in Australia towards the end of summer (they may even be met with in December—Australian mid-summer), or in the early autumn. But "corn-mildew", as this stage of the blight is termed in England, or "black-rust" as Mr. McAlpine prefers to term it,* does not seem to be so prevalent with the Australian rusts as with the corresponding English ones. These *teleutospores* only give rise to *sporidia* that, *ex hypothesi*, are incapable of germinating save on those plants that act as intermediate hosts. As regards the "orange-red" rust, which Mr. McAlpine identifies with *Puccinia graminis*, this would, were the determination correct, imply the power of germinating only on a *Barberry*. But no Barberry is wild in Victoria and none are grown to an appreciable extent; it is, therefore, says McAlpine, asserted that this phase of the rust is gradually dwindling away in Australia, from its being not only of no advantage to the species but rather a waste of energy to produce *teleutospores*. This is the hypothesis favoured by those who, while believing that the most destructive Australian rust is *Puccinia graminis*, decline to accept without direct proof the statement that its *teleutospores* can produce *sporidia* capable of germinating anywhere except on an intermediate host (SUB-CONF. L. 28).

In Australia, however, Mr. McAlpine states, there are those who believe that the *teleutospores* of this "orange-red" rust, supposed by him to be *P. graminis*, produce *sporidia* that

* A somewhat unfortunate selection of name on Mr. McAlpine's part, because "Black-rust" is the general term throughout Europe for the rust which is known as *Puccinia graminis*.

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can germinate on, and reproduce the red-rust in, the growing wheat of the next season.

As a practical matter, Mr. McAlpine considers both theories, and is himself inclined to think from his own personal observation and from what old farmers have told him, that the "black rust" (meaning by this the teleutosporic stage of the "orange-red" rust) is dying out considerably, the explanation being that the fungus, owing to the comparative absence of the Barberries required as intermediate hosts, is ceasing to produce *teleutospores* (SUB-CONF. L. 29). [It should be observed, however, that Mr. McAlpine gives no information as to the number of seasons that he has made this point a subject of personal observation, and does not explain the standard of comparison employed in coming to this conclusion.]

The other hypothesis, that *teleutospores* are *not* disappearing, but have acquired the habit of producing *sporidia* that can germinate on wheat, has also received Mr. McAlpine's attention. On this point "all that can be said at present is that wheat-plants infected with germinating teleutospores during the past season (1892-93) developed the red rust *earlier* than those growing alongside of them" (SUB-CONF. L. 29).

Dr. Cobb (New South Wales), during the discussion at the Second Conference, while admitting the connection between *Puccinia graminis* and the Barberry plant, said that its *æcidium* had not, so far as he knew, been found in Australia, but that in any case "*it is not true that the Barberry stage is necessary in Australia for the production of* P. graminis." As to *P. rubigo-vera*, Dr. Cobb added, it exists all the year round, even in Europe, in the red-rust stage (II. CONF. 37). He does not, however, mention any experimental proof that in Australia it can pass to wheat from any of its collateral hosts; the evidence from America and from Europe is altogether against this being usual. In New Zealand, as in Australia, experience seems to throw doubt on the necessity for an æcidial stage in the rust supposed to be *P. graminis* (SUB-CONF. M. 54).

It will be seen that, so far as Australia is concerned, there are two important and dangerous rusts, one a "yellow" or "spotted" early rust which has been identified with *Puccinia rubigo-vera*, another a later "orange-red" or "streaky" rust which has been identified with *Puccinia graminis*. It will be noted also that, while both are admittedly serious rusts, there is not perfect unanimity as to which is the more destructive. The balance of opinion is in favour of the later rust being the

more fatal in ordinary seasons; in very rusty years the balance of evidence, as presented by the Australian literature on the subject, is in favour of the early rust being the more dangerous. It will be noted, moreover, that, according to Eriksson and Henning, the most competent judges on this point, there is no such rust as *Puccinia rubigo-vera.* They seem to consider the early Australian rust identical with the European *P. glumarum*, for which no intermediate host is known, even in Europe. And it may be pointed out that there is every probability that the later rust, which Australian authors identify with *P. graminis*, is not that species either. The metric characters given by Dr. Cobb (COBB, CONTRIB., vol. I., pp. 201, 202) for the Australian *P. graminis* certainly can hardly be said to deviate markedly from those given by Eriksson and Henning for the European one. But the very considerable limits of variation :—

Uredospores	European . . .	17—40 × 14—22 μ.
	Australian . . .	30—40 × 18—22 μ.
Teleutospores	European . . .	35—60 × 12—22 μ.
	Australian . . .	35—65 × 15—20 μ.

will lead even those unfamiliar with the subject of *Puccinia* to be unwilling to admit that measurements alone are sufficient to warrant the conclusion that the two are necessarily specifically identical. This feeling of doubt is not decreased by Dr. Cobb's observation that now and then, in the Australian *P. graminis*, he has seen pustules " in which all the *uredospores* appeared almost as if two-celled " (COBB, CONTRIB., vol. I., p. 201), and his statement that he finds on a native Australian grass (*Agropyrum scabrum*), a rust which is absolutely identical with the Australian *P. graminis* as to structure, "if we except this difference that among its red-rust spots there are certain black bodies which may constitute a fourth spore of the rust." Dr. Cobb recognises the fact that this may show that the rust on *Agropyrum* is different from that on the wheat, and the point had not been experimentally tested when the statement was made (II. CONF. 34). It also leads to a desire for experimental trial as regards the supposed *P. graminis* itself.

This experimental test has been apparently applied. Mr. McAlpine says that " having determined the kind of rust affecting the wheat plots to be *Puccinia graminis*, the next point to settle was if it would affect the Barberry when sown upon it, as it is asserted to do in Europe and America." Taking *teleutospores* which, on being tested, were found to germinate, Mr. McAlpine proceeded to inoculate plants of four different

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species of Barberry, at least two of which are known to carry the æcidial stage of *P. graminis*. The experiment in one case was conducted under a bell-jar; Mr. McAlpine does not say which of the four species tested was so treated. "The plants were carefully watched and tended, but no result appeared" (SUB-CONF. L. 30). Mr. McAlpine, it must be admitted, draws no express conclusion from this experiment. What conclusion he expected to be able to draw is not altogether clear. Since it happens that the power which its *teleutospores* have of producing *sporidia* that can germinate on certain Barberries is one of the diagnostic characters of *Puccinia graminis*, one might have expected the settlement of the point to have preceded any absolute determination of the species. Mr. McAlpine is content to reverse the process; the result of his test is, however, to lead the ordinary mind to suspend its judgment as to the identity of the "orange-red" Australian rust with the European *P. graminis*. The identity of the two has certainly not been made out, and so far as the evidence of Australian authors goes, is not highly probable.

Rust in India.

§ 14. The Indian rusts on cereals have not, like the European, American and Australian rusts, been made the subject of detailed study, prolonged over five or six seasons by capable and competent observers, specially deputed for the purpose. Consequently less is known regarding them. As in the case of Australia, however, it has been customary to suppose that there are two principal rusts, one of these being identified with the European *P. graminis*, the other with the confused and indeed non-existent *P. rubigo-vera* (*Agricult. Ledger*, 1895, No. 20, pp. 36, 45); *Puccinia coronata*, though known to occur in India, has not been found on any cereal crop.

As a matter of fact, there are in India at least four very distinct rusts on wheat alone with another that has so far only been found on barley. These are briefly described in a Note published in the *Records of the Botanical Survey of India* (vol. I., pp. 99—124) in 1896. In that note any attempt at identifying them with European rusts has been sedulously avoided and names have been given them merely with reference to the places where they were first seen during a tour undertaken in search of wheat-rusts.

One of these, termed the "Mozufferpur Rust," had some of the features of *P. graminis* for which it is usually taken and under which name it is included in Dr. Watt's review of Indian fungi. The structural and metric characters of the

" Mozufferpur Rust " do not, however, quite agree with those of *P. graminis*, the latter in particular having a much more limited range of variation. The pustules are differently disposed, and it is notable that, though it affected both wheat and barley as *P. graminis* does, it did so equally, whereas *P. graminis* is less severe on barley than on wheat; at the same time, this Indian rust left oats untouched, whereas *P. graminis* appears on that crop also. This last feature would render it equally doubtful if the Australian *P. graminis* be the same as this Indian rust. The æcidial stage of this Mozufferpur Rust has not been found.

Another, the " Ferozepur Rust," has all the characters that are credited in botanical works to "*P. rubigo-vera*," that is to say, to the *Puccinia*-stage of *P. glumarum*. And it is now less improbable that this rust *is* the same as the European one; the great difficulty hitherto has been the absence of its æcidial stage from any of the Indian Borages (*Agricult. Ledger*, 1895, n. 20, p. 46). As Eriksson and Henning now are able to tell us that its connection with any borage is probably an illusion, and that even in Europe the rust either does not have, or does not necessarily require to pass through, an æcidial stage, it is far from unlikely that the "Ferozepur Rust" may turn out to be *Puccinia glumarum*. But if this be so, and if this be therefore the *P. rubigo-vera* of most European and Australian writers, it must be recollected that it is not, or is only very partially, the *P. rubigo-vera* of Indian authors.

Both these rusts are probably of heterœcious type; that is, they either have an æcidial stage on an intermediate host or can dispense with the intermediate stage. At any rate, they both have teleutospores on wheat. For what seemed another form of the " Ferozepur Rust " from Lahore this is not absolutely clear, since no teleutospores were found; it may, however, only have been that they had not yet had time to appear. This " Lahore Rust " showed the further peculiarity of possessing two differently coloured and differently sized series of *uredospores*.

Another wheat-rust, " Saharanpur Rust," had no teleutospores, though it does not follow that it never has any. Its pustules appear to be somewhat like those of an unnamed Australian *Puccinia* on wheat (COBB, CONTRIB., vol. I., p. 202), and though the measurements of the spores hardly agree, it must be recollected that Dr. Cobb's measurements were probably made from fresh material, while those of the Indian rust were made from specimens collected some time before.

A barley-rust, termed the " Mogul Serai Rust " in the

paper referred to, is there compared with what had hitherto been a doubtful European rust (*P. simplex*) referred by many authors to "*P. rubigo-vera*;" the appearance, since the *Note* was issued, of Eriksson and Henning's full account of this European rust makes it probable that the two are distinct; they agree in being apparently confined to barley; they differ, however, very considerably as regards size of *uredospores*. The *teleutospores* of "Mogul Serai" rust are not yet known; nor is its æcidial stage, if it has such.

The last and apparently by far the most important Indian rust is one described in the *Note* referred to as "Shibpur Rust." It seems to be this that usually does most harm in India, and it is this that, as a rule, is referred to by Indian authors as "*Puccinia rubigo-vera*." All the other European, Australian or Indian rusts are, or may be, of the heterœcious class; this seems to be one of the autœcious class of *Puccinia*, or one of those that require no intermediate host, because their *æcidia* are carried by the same host as carries their *uredospores* and *teleutospores*. Only *uredospores* of this have been found on wheat, and it is as certain as any fact dependent on negative evidence ever can be, that it does not form teleutospores on wheat at all. All that affects the wheat in this case, therefore, is the *uredo*-phase of the *Puccinia*-stage of a rust that does not appear to be distinguishable from one, both the stages and all three parasitic phases of which occur together on a common Composite weed, *Launea asplenifolia*. As this weed has a perennial rootstock of considerable dimensions, the necessity for the formation of teleutospores does not at first sight seem evident. The plant possesses, however, the peculiarity of being absolutely leafless from June to October, throughout the whole rainy season in fact, and as the mycelium of the fungus has not been found to be able to penetrate the tissues of the rootstock, the formation of resting spores seems essential to its continuance. In this case, therefore, the appearance of the *uredo*-phase on wheat is an accident so far as the life-history of the fungus itself is concerned; it is, however, an accident that in certain seasons and under conditions suitable for the spread of the fungus is most detrimental to the wheat-crop.

The belief is fairly general that rust attacks other plants besides wheat. Thus it is reported that in South Australia "marsh-mallows" carry rust (II. CONF. 50). They do so certainly, but the rust on marsh-mallow has nothing to do with the rust on wheat (III. CONF. 17). Flax too is badly rusted in Australia, but not by the wheat-rust (II. CONF. 16).

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The same is the experience in India. In the *Resolution on the Revenue Administration of the Central Provinces* for 1894-95, the Deputy Commissioner of Jubbulpore is quoted (p. 2) as follows :—"The cloudy and damp weather induced a very severe attack of our old enemy, red-rust. This appeared, as usual, in linseed first, and then spread to wheat." As the Chief Commissioner points out, on the next page, "the fungoid disease which attacked the linseed was distinct from that which attacked wheat. It was a common thing to see stray wheat-plants unaffected in a reddened linseed-field, and *vice versâ* a solitary linseed-plant in a wheat-field was found to be the only plant affected." The rust on linseed is a *Melampsora*, not a *Puccinia* (*Agricult. Ledger*, 1895, n. 20, p. 101).

Rust in America.

§ 15. In America it is stated that a wheat-rust, said to be "*Puccinia rubigo-vera*," and which may or may not be *P. glumarum*, passes the winter in the tissues of the wheat-plant in a mycelial condition; the warm weather of spring induces a crop of spores which may, under favourable conditions, spread the disease; the infection of winter-wheat is materially aided by "volunteer," or self-sown wheat, which carries the rust through the few months following harvest; finally, that the red-rust spores are capable of maintaining their power of germination through the winter, and thus of infecting the crop in the following spring (*Agricult. Ledger*, 1895, n. 20, p. 55). Granting that these results are satisfactorily proven, they are not of practical moment for us in India. We have no wheat in the plains in the hot-weather and rains corresponding to winter-wheat in America, we have no volunteer wheat capable of bridging the gap between the harvesting of wheat at the beginning of the hot-weather and the sowing of the next crop at the end of the rains; finally, we know that the red-rust spores of the Indian rusts, so far from maintaining their power of germination for several months, lose them in from 24 to 36 hours (*Rec. Bot. Surv. India*, I. 117). The facts in Europe accord with those in America, though the American explanation does not suffice to account for them; *no mycelium is to be found in the tissues of the wheat-plant in winter* (APPEND. A., p. 76). In America, as in Australia, it is stated that the earlier rust does little harm; the later rust is said to be the dangerous one (SUB-CONF. H. 4).

Time of Appearance of Rust.

§ 16. The time of appearance of rust varies in different districts and indeed does so in different years for the same district, the state of the weather hastening or retarding its appearance. The dangerous season in Victoria is generally given

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as from the beginning of October to early November (II. Conf. 15). This applies to Southern Victoria; in the northern districts November-December is the month (III. Conf. 17). The dangerous period is sometimes set down as extending over six weeks (II. Conf. 15).

The month of October is the critical time in New South Wales (II. Conf. 32). It is usually first observed in October, November or December, especially October and November (III. Conf. 14). The earlier the attack the more serious it is, since it is probable that at first only the lowest leaves are affected; if wheat has got beyond the flowering stage and the rust remains confined to the flag, the farmer is assured of obtaining a crop, though, of course, a less valuable one than in a non-rusty year (II. Conf. 36).

In South Australia the experience is that rust is generally first noticed about or shortly after the wheat comes into flower (II. Conf. 50). This is noted in other Colonies also, *e.g.*, Victoria (II. Conf. 17), and New South Wales (II. Conf. 32).

It is believed, and very probably justly so, that on going through any wheat crop at any season of almost any year and in almost any district, specks of rust may be found. All that is required for a general spread is a suitable condition of weather. The "breaking-out" of rust noticed by a farmer is probably *never the first breaking-out* (II. Conf. 37).

In spite of the nature of the facts it is said that many Australian farmers do not believe that rust is infective, but assert, on the contrary, that it *never* spreads. One Victorian farmer is quoted as basing his belief that this is so on the fact that in a particular season he had 60 acres of oats rusted, while 50 acres of wheat adjoining were free, "the oats receiving heavy rain while in blossom, while the wheat received the moisture when required—just before it burst into ear." This instance is commented on by Mr. McAlpine (Victoria) as follows:—"Here we have an illustration of rust not spreading, for the simple reason that the conditions were favourable to its spread in the one case (oats) and unfavourable in the other (wheat)" (II. Conf. 16). [It is of course equally possible that the rust which affected the oats may have been one that does not affect wheat at all; in any case, it is interesting to find that this popular belief is probably more correct than the opinion put forward by many trained observers.]

The Victorian experience is that the time which elapses between the first attack and the "spread" of rust averages from 12-15 days (III. Conf. 17), but in South Australia, and pro-

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bably elsewhere, it has been found, when the conditions are favourable, to spread continuously from its first appearance (II. Conf. 50).

The accepted view of the Australian delegates is that, though undoubtedly infective, rust is not in any degree hereditary (II. Conf. 21); the view expressed by Eriksson, in the latest contribution to the literature of rust, is practically the reverse (Append. A, p. 75): the facts of the case, it must be admitted, are all in favour of the European observer's view.

The experience in India agrees very closely with that in Australia; sometimes the wheat is attacked by rust when it has little more than appeared above-ground—at other times not until it has almost or quite come into bloom. In the same season, too, it may be prevalent in particular districts and not in others. Thus in 1894-95, when it was prevalent in the Central Provinces, it was a noticeable feature of the season as well as of its predecessor that the damage by rust grew greater the further up the Nerbadda Valley one proceeded (*Resolution* on *Rev. Admin., C. P.*, p. 2). In 1895-96 rust was prevalent in Bengal and Tirhut, but could not be found in South Behar, the Central Provinces, Central India or Rajputana; it occurred, but was not severe, in the Punjab, but was not to be met with in Oudh (*Rec. Bot. Surv. India*, vol. I., No. 7).

Secondary Causes of Rust.

§ 17. It is evident from what is said in the preceding paragraphs that until the life-history of each of the wheat-rusts, in all the countries where wheat is grown, has been precisely ascertained, there is little hope of being able to prevent rust by the eradication of the blight itself. If, indeed, the latest theory of rust be accepted, its eradication seems impossible. Attention must therefore be directed to the secondary or mediate causes of rust,—the conditions, inherent or accidental, that render wheat liable to rust. For the factors that increase the susceptibility to rust may be said to be of two kinds: those characteristic of the plant, those induced by its environment. The former are generally supposed to include a soft succulent condition of the tissues at the period when the rust-spores are abroad. This condition may of course be inherent in the variety of wheat which will consequently deserve to be classed as a "rust-liable" variety, or it may be induced by the environment—by the presence of moisture in the soil and the other conditions going to make a "rusty locality" as well as by the occurrence of a moist and still atmosphere accompanied by heat, these being the factors that go to make "rusty weather" and to induce a "rusty season." The most recent

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experience, however, goes to show that the influence of at least two of these factors,—the state of the tissues and the circumstances of the environment,—have been exaggerated and misunderstood (APPEND. A., p. 74).

Varieties with little silicon in their composition are always prone to rust (II. CONF. 42). But even varieties naturally well-protected are liable if caught at a susceptible stage; this all the more readily if they be growing in a rich soil and so showing a broad and heavy foliage. For the broad and heavy flag required in England to evaporate as much moisture and to give as much exposure to sunlight as is possible in a climate so gloomy and so damp, is not advisable in a sunny climate like that of Australia. It does no good in ordinary seasons, and is a source of danger in rusty ones (II. CONF. 42). Moist and cloudy weather is apt to induce in any variety these undesirable characters; the want of sunshine diminishes the vigour of the plant, while the dampness increases the growth of leaf. There is more infective surface and at the same time less power to resist the infection (II. CONF. 32).

Wheats with a spreading flag are more liable to infection than those with an erect leaf (III. CONF. 35); as are those with a green foliage and unprotected by a waxy bloom.

Harvests in which rust has been bad have, generally in South Australia, been late ones (II. CONF. 50), and late maturity in a variety of wheat is exceedingly apt to expose it to infection by rust (II. CONF. 42).

In India it has been observed that those wheats with a soft starchy grain appear to suffer more from rust than those with a hard glutinous grain, as do those that have a broad leaf as opposed to those with a narrow flag. But perhaps neither of these characters is altogether directly responsible for the liability; those wheats that ripened late, however, very evidently suffered most (*Rec. Bot. Surv. Ind.* I., p. 101).

An insect related to the Hessian fly, when in the larval stage, is found in New South Wales to *feed on* the rust spores. It, however, also spreads the spores and so does more harm than good. By the Agricultural Department of the Government of New South Wales it is thought that this insect is responsible "for a very large amount of loss to the country by assisting the spread of the rust-fungus" (II. CONF. 35).

The subject of self-sown or "volunteer" wheat as a mediate cause of rust in the regular crop has been somewhat fully discussed at the Australian Conferences. In Australia there is no doubt that a self-sown crop may be rusty, but the

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experience of some Victorian farmers is that any grains that drop from the harvesting and come up the following year, lie exposed, grow with the early rains and, if not killed in cultivating, are much more forward than sown grain and are rarely affected with rust (II. CONF. 22). This is the experience that accords with expectation and that is in line with the recommendation to sow early, in order that rust may be avoided—sowing too soon being a much safer error to commit than sowing too late (II. CONF. 10).

In Queensland, however, it is found that "volunteer" wheat is particularly liable to rust (SUB-CONF. J. 15), and a more recent census of opinion in Victoria has brought out the fact that, of 32 cases, the majority found self-sown wheat more rusty than ordinary wheat, while 9 found it to appear earlier on the self-sown than on the ordinary kind (III. CONF. 20). There is thus no doubt a risk attaching to the presence of self-sown plants. There is said to be little doubt that the presence of self-sown wheat is one of the factors enabling the *uredo*-stage of wheat-rust to be continuous throughout the year between one wheat crop and another (III. CONF. 29). It is, therefore, very advisable to keep down all self-sown wheat by means of sheep (III. CONF. 21).

The subject of volunteer wheat is not one that is likely to be of practical interest in India, for it may be doubted if any plants are likely to germinate; or, should they do so, to survive through the hot-weather that immediately succeeds the wheat harvest.

The two chapters that follow will be found to deal with these mediate causes of rust; it has seemed more convenient to reverse the order indicated in the paragraphs immediately preceding this, and to deal first with the accidental causes and with the remedies for those that have from time to time been tried.

CHAPTER III.—RUST-PALLIATION.

Rusty weather.

§ 18. Rust is usually most prevalent in seasons when the rain-fall is excessive, especially during October and November (II. CONF. 17, 49), and particularly if the wet season follows a warm spring (II. CONF. 50). Mere excess of rain-fall is not, however, sufficient to induce rust; it depends on the weather that follows (II. CONF. 47; III. CONF. 14). If clear weather, as is usual in Queensland, succeeds the summer rains, rust does not occur (II. CONF. 47). When close, damp, muggy weather sets in, then rust is certain to appear (II. CONF. 17, 28, 32, 47, 50);

III. Conf. 14); it spreads most rapidly in calm hot days and dewy foggy nights (II. Conf. 17, 28), its progress being especially rapid if a heavy dew at day-break is followed by a hot sun (II. Conf. 46).

A dry cold season in Queensland is inimical to rust (II. Conf. 26), and a good high wind, especially a dry north one, is supposed at times to save the crop in Victoria (II. Conf. 17). In Queensland the belief is that rust appears during or after a thunderstorm; if this be followed by a westerly wind, the rust makes no headway (II. Conf. 28).

The year 1889, which was a very rusty one, was marked in New South Wales by frequent thunderstorms at the time the wheat was in bloom (II. Conf. 32). The colder districts were in that year less rusty than the others (II. Conf. 33).

A heavy downpour of rain is supposed to enable wheat to throw off rust. This is not, however, always the result; in any case the farmer's opinion that the rust has been washed away does not accurately represent what has happened. The mere fall of rain cannot wash out the fungus within the tissues of the plant, and could hardly arrest its growth. Perhaps the result of the rain-fall is to induce a sudden increase in the growing energy of the wheat-plant and to alter the conditions favourable to the growth of the parasitic fungus that constitutes rust. Perhaps, too, the lower temperature that often accompanies a fall of rain may help to check the growth of the rust (II. Conf. 17) just as hot, muggy weather favours its spread. In the same way, too, hot, muggy weather appears to change the character of the culm, and renders it liable to be attacked as well as the leaves; if only the flag be attacked, the grain is not ruined; if the stem also suffer, the grain does not form (II. Conf. 32).

Rust is said always to be worst in sheltered spots where the soil is damp, where mist lodges and currents of air do not readily reach the crop (II Conf. 19), and in particular districts particular exposures are said to be more affected by rust than others. In other districts some exposures, for instance, a seaward aspect with the concomitant influence of sea-winds, are said to be inimical to rust (II. Conf. 50). But no particular exposure or elevation, and no particular prevailing wind, confers complete immunity (II. Conf. 17, 19).

It is supposed in Victoria that, if January and February be wet, rust is inevitable, and it is recorded that at least one farmer advocates that no crop be put in if the apple-trees blossom in those months (Sub-conf. L. 39).

In India, also, rust is favoured by cloudy and damp weather

(*Resol. Rev. Admin., C. P.*, p. 2) or by sultry weather with an overcast sky (*Rep. by Commis. Settlement & Agriculture, C. P., on cross-bread Wheats*, 1897, p. 2) or by heavy morning fogs followed by heat (*Rec. Bot. Surv. Ind.* I. p. 82); the opinion of the Commissioner of Settlements and Agriculture, C. P., was that in 1897, after the sky became clear, the spread of the rust spores was checked by the strong sunshine.

Rust and Drainage.

§ 19. The question of moisture in the soil has been debated at some length. Rust is always said to be worst in hollows where water lodges (II. Conf. 19), and drainage is said to be perhaps the most important measure the farmer can take to mitigate rust; undrained land is always moist, and in some cases is the only kind at all affected. This is the opinion and general experience in Victoria (II. Conf. 18, 21), South Australia,—though there drainage is hardly practicable (II. Conf. 47, 50), and New South Wales (III. Conf. 15). It is, however, recorded that, although drainage, when its effect was experimentally tested in Victoria, induced a higher outturn it did not appear to affect the rustiness (II. Conf. 8), and when the experiment was repeated it was found that of six places artificially drained, five were rusty.

Dry or Damp Seed-bed.

§20. The experience as regards seed-bed seems equally variable. A dry seed-bed is strongly recommended in Victoria by all who refer to the subject,—sowing on a dry bed meaning, it is said, comparative freedom from rust, sowing on a moist seed-bed greater liability to affection (II. Conf. 16). In Queensland, on the whole, a dry seed-bed is supposed to be helpful as an escape from rust; why, Mr. Shelton, the Government Instructor in Agriculture, is not prepared to say,—if indeed it be true at all (Sub-conf. J. 15). Farmers who are of this opinion prefer to sow at once after ploughing, if the condition of the soil be otherwise favourable, and trust to rain coming to start the seed. But in Queensland some farmers decline to put their seed in a dry bed, preferring to wait for a shower, so as to ensure germination. Moreover, in some soils, where the land breaks up rough, the farmer prefers to wait for rain to enable him to harrow and pulverize the clods and so get a more even seed-bed (II. Conf. 28).

Rust and Irrigation.

21. The question of irrigation is also an important one. At an Irrigation Conference held at Melbourne in 1890, it was considered [probably by those in favour of irrigation, as such] that irrigated crops were not more affected by rust than unirrigated. The experience of others in Victoria has been that there was some rust on irrigated crops when there was none

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on unirrigated, and that rust was always worst on land irrigated during very hot weather (II. Conf. 18, 19).

It is stated also that in South Australia if a plot of land be heavily watered in the middle of summer and another plot be left unwatered, wheat sown in the watered plot will have much rust, wheat sown in the other will have little (II. Conf. 47). It would seem then as if irrigation were accompanied by drawbacks whether applied before or during the time the crop is in the ground.

Mr. Shelton (Queensland), speaking of his experience in Colorado, where he had himself been a wheat-grower and where, with a rainfall of only 10 inches *per annum*, every thing had to be irrigated, says he never saw or heard of rust there (II. Conf. 47).

It would appear that mere moisture in the soil is not enough to cause rust. Thus Mr. Kelly (South Australia) gives an instance of 10 acres of wheat, which was irrigated twice, yet showed no rust. "No rain fell on that wheat." He cites also the experience of wheat-growers in Chili where the crop is raised entirely by irrigation with snow-water and there is no rain. The soil is saturated fortnightly in this way, yet as a rule there is no rust. In certain years, however, the air becomes humid; the irrigating water is neither completely absorbed by the soil nor completely evaporated, but lies about in pools. When this continues for any length of time, rust appears. In 1862, a year of this kind, one farmer who abstained from irrigating saved his crop while his neighbours had theirs rusted (II. Conf. 47).

Mr. Pearson (Victoria) gives probably a sound opinion when he says that, while it may be true that sometimes irrigated wheat is freest from rust, at others suffers most, there is no doubt that irrigation judiciously applied is beneficial (II. Conf. 47). Indeed, Mr. McAlpine (Victoria) at the following Conference made the definite statement that irrigation applied early in the season does the crop good, and does not induce rust, though, if applied when the wheat is in flower, it causes very bad rust (III. Conf. 19).

The experience in the Central Provinces in 1897 with cross-bred wheats that were expected to be rust-resistant was that they suffered from rust. This was suspected to be partly due to the necessity there was for irrigation, owing to the abnormal dryness of the season and the soil. Water was applied seven times up to March 6th, the last application was made though the plants were not in need of irrigation, in order to discover

whether watering encouraged the rust-spores to spread. In the event it was observed that rust did spread to a certain extent (*Rep. by Commiss. Settlements and Agric., C. P., on Cross-bred Wheats*, 1897, p. 2).

Rust and soils.

§ 22. According to the Australian farmer crops on rich soils suffer most from rust (II. Conf. 17, 82); fallow-land being usually most affected (II. Conf. 19). This is the general experience in South Australia, and in rusty years the best crops have in many cases been reaped from the poorest soils or from exhausted fields (II. Conf. 49). One observer, however, thinks wheat should never follow wheat (II. Conf. 21). Light limestone and sandy soils always suffer less than loams and clays (II. Conf. 50).

In New South Wales clay surface and a clay sub-soil are bad because of the tendency to rust (III. Conf. 15); in Victoria the experience is that loam, clay or strong land suffer least; next comes a sandy soil; black soils suffer most, though chocolate soils are almost as bad (III. Conf. 19).

The explanation is obviously not the result of any *direct* connection between rich soil and rust. Rich soils and fallow lands naturally yield heavier crops; heavier crops mean more luxuriant vegetation, therefore softer tissues, and, as a consequence, greater susceptibility to the infection (II. Conf. 19, 49). In keeping with this is the experience in South Australia that rust is worst in those years when the crop is otherwise best (II. Conf. 50). The objection to wheat following wheat is the possibility of self-sown wheat-plants appearing in the interval between the two crops and harbouring the rust in the meantime; such plants, termed "volunteers," are said to be particularly liable to be affected (Sub.-conf. J. 15). In Queensland wheat on scrub-lands is said to be particularly liable to rust (Sub.-Conf. J. 14).

Rust-free areas.

§ 23. In notoriously rusty districts in Queensland certain areas are never damaged by rust (II. Conf. 28). Their existence is not explained by Mr. Shelton, who called attention to them at the Second Conference, although they formed the subject of a prolonged discussion (II. Conf. 30, 31). The phenomenon appears to be undoubted.

The Mallee districts of Victoria are said also to be peculiarly rust-free, and so are the Murray Flats in South Australia; the explanation given of the comparative immunity from rust in these areas is that the crop ripens early—harvest beginning in October—and that the rain-fall is light. It is, however, contended that the phenomenon in Queensland is,

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of a character that neither light rain-fall nor early growth will satisfactorily account for. It is true that in Victoria and elsewhere in any season one field may be found free from rust and an adjacent one be badly affected, and that the circumstance may be explicable owing to differences of local conditions as to drainage, position as regards wind, etc. But the point as regards these areas in Queensland is that even in rusty districts, and even on low-lying and black soils the crops in these rust-free fields growing beside and reaped along with rusty crops, *always remained rust-free* (II Conf. 31).

Rust and cultivation; Ploughing.

§ 24. Intimately connected with this is the question of the treatment to which the soil is subjected beforehand The effects of ploughing—deep as opposed to shallow—are doubtful. In Victoria both were found, in experimental observations, to be equally rusty; the deeply ploughed gave the heavier crop, thus favouring the development of rust indirectly (II. Conf. 8). Still in Victoria a general census of farming opinion showed that it was supposed in that colony that shallow-ploughing favoured rust (II. Conf. 18). In South Australia, on the other hand, deep-cultivation was supposed to favour rust (II. Conf. 50); when the facts were looked into it appeared that deep-ploughing was really not so good; at all events the average depth of ploughing, in lands reported rusty during 1891-92, was 6½ inches, the average depth in rust-free lands only 5½ inches (II. Conf. 14). But in the same year in Victoria the results were so evenly balanced (III. Conf. 19) that it is doubtful if they had anything to do withthe question; it is admitted, however, that the statistics and experiments recorded are not quite conclusive (II. Conf. 18; III. Conf. 48).

Harrowing the standing crop.

Harrowing when the plant was 2 feet high is reported in one case to have been followed by improved yield of grain "and the crop was very slightly affected by rust" (II. Conf. 21). [It does not follow that the freedom from rust depended on the harrowing.]

Rotation.

Rotation of crops is strongly recommended by Dr. Cobb. The reason why wheat gets diseased, if grown continuously in one place, is two-fold: –

(1) The soil is exhausted of those constituents that wheat specially draws upon.

(2) The enemies of wheat, at first few in a new country, year by year increase unchecked Rotation, or a careful system of fallowing, will tend to check the proneness to increase of these enemies, and among them of rusts.

No method of combatting rust is more rational, therefore, than rotation (Cobb. Contrib. vol. 3, p. 183). This is more or less advocated by others (II. Conf. 21), Mr. Pearson (Victoria) thinking that for his colony the time for a general adoption of rotation has already arrived (II. Conf. 38). Indeed rotation is recommended because fallow-wheat and wheat after green-crop is said to be less rusty than wheat after wheat (II. Conf. 30, 33). It appears, indeed, that particular rotations are advisable; it is stated that wheat after mangolds proved more free from rust, less flaggy, stronger in the straw, less lodged and altogether a better crop than after potatoes (III. Conf. 45). In any case it is recommended that a field in which rust has appeared in one year should be left fallow the next (II. Conf. 33). One New South Wales farmer adds that wheat should not be sown too soon after ploughing; the delay, he thinks, gives a harder and more healthy straw (II. Conf. 33).

There is, however, another side to the question. Mr. McAlpine (Victoria) finds the results from rotation in Victoria very inconclusive (III. Conf. 19). In South Australia—where at present wheat is sown in fallowed land, the stubble is eaten off by sheep, in the following season the land is well worked, and wheat is again put in (II. Conf. 45)—it is found that high farming and rich soil operate in increasing the liability to rust, always supposing that the climatic conditions favour its development (II. Conf. 50).

Rust prevails with all kinds of cropping but seems to be always worst when the cultivation is good. Thus Mr. Lowrie (South Australia) finds that in the Experimental Farm at Roseworthy, well-tilled, well-manured, well-rested and new lands suffer most. Low-lying, rich or fertile flats are quite the worst, but new lands and manured fields also suffer badly (II. Conf. 50).

Fallowing.

In Victoria it was found in 1891 that fallow land was not more rusty than old land; while it did not seem that cropping any number of years added to the risk of rust (III. Conf. 19).

The opinion regarding fallowing is, in South Australia, divided; some advocate, others condemn the system. Mr. Lowrie thinks that the apparent exemption from rust which fallow-land in some cases enjoys is due to its being the custom to sow bare fallow-land first in the season and the crop is raised and ripened sufficiently early to escape the rust. On the other hand, wheat after wheat, being presumably more

dwarf and stunted than wheat after fallow, would suffer less from rust than the luxuriant crop after fallow if the two are sown together and are equally exposed to infection (II. Conf. 50).

Mr. McAlpine (Victoria) in giving a summary of recommendations (III. Conf. 21) advises working the land dry, cultivating deeply, draining thoroughly and sowing seed in a dry bed.

Mr. Bayne (New Zealand) also advocates good agricultural methods as the best means of combatting rust, among these being clean culture, judicious rotations and fallowing of land (Sub-conf. O. 493).

Burning Stubble.

§ 25. Whether the stubble should be burned before wheat is put in, is a much-discussed point. One observer strongly advises it (II Conf. 21) as a wise precaution since it destroys any spores of rust that may be about. It will not, however, be fully effective unless the weeds that may harbour the rust in adjacent paddocks and along headlands are rooted out and burned also.

In Queensland only about 20 per cent. of the farmers had experience of the treatment. Those who have tried it favour it (II. Conf. 28), and it is officially recommended (II. Conf. 30) for the Colony.

In New South Wales the results and opinions are rather contradictory (II. Conf. 32) and not much is known about it (III. Conf. 15). Some of the farmers recommend it ; so does Dr. Cobb (II. Conf. 33, 35). Mr. Farrer (New South Wales), on the contrary, is much opposed to it owing to the waste of humus-forming matter (II. Conf. 40) ; to this Mr. Pearson (Victoria) replies that while this is true, it is better to sacrifice the humus and avoid the risk of losing 50 per cent. of the wheat-crop, if keeping the stubble means harbouring the spores of rust (II. Conf. 44). Mr. Shelton (Queensland) too, while agreeing with Mr. Farrer that it is inadvisable to burn "straw" (after the stripper), thinks there is no harm in burning "stubble" (after the reaper) for at best the stubble is rough and is not a good fertilizing material (II. Conf. 45). On reconsideration Mr. Farrer was prepared to permit the burning of stubble if done immediately after harvesting and if followed by a catch crop of cow-peas (II. Conf. 41, foot-note).

In experiments conducted at Port Fairy (Victoria), it was found that a plot where the stubble had been burned bore a heavier crop and was less affected by rust, and this, although it was *on the sheltered side of a fence* (II. Conf. 8), and there-

fore in other respects less favourably situated. But later evidence from Victoria was decidedly against the burning of stubble being of the faintest use (III. CONF. 20), and this is the South Australian experience also (II. CONF. 51).

In South Australia there was many years ago a law preventing the burning of stubble and in those days the crops of wheat were excellent; at that time, however, the farmers knew nothing about rust (II. CONF. 45).

§ 26. Besides the mere physical treatment of the soil, the question of special applications, including, of course, manures proper, has also been carefully considered at these Conferences. **Manures.**

Of manures proper, farm-yard manure almost always gives the worst results. In Victoria the crop on patches experimentally grown with farm-yard manure was sickly from the first (II. CONF. 7). In New South Wales also, farm-yard manure produced a flaggy, much-rusted crop (II. CONF. 33); the same was the experience in South Australia (II. CONF. 50). In Queensland little manure is used, that little being mostly farm-yard, and it did not seem to have any bad effect; it was, however, admitted that the year under discussion (1890) was a year of little rust in any case (II. CONF. 28). It is not, however, in Queensland alone that the ill-effect of stable-litter and farm-yard manure is denied (II. CONF. 18), but the evidence against its use is fairly strong, for 24 out of 31 of those who used it report badly of it. The rusting is evidently not a direct result of the application of manure, but is induced because the manure promotes a rank growth and a tendency to lodge (itself an indication that the straw is weak), and thus prevents the free passage of air among the straw (II. CONF. 7; III. CONF. 42). The rank growth, moreover, causes delay in ripening, which is also a factor increasing the risk of rust (SUB-CONF. J. 15).

Nitrogenous manures have been found in South Australia to favour rust, while phosphatic ones rather tend to diminish it. (Mr. Lowrie, III. CONF. 65). In New South Wales, Mr. Anderson states that phosphatic manures ripened the wheat 10–14 days earlier and such crops were doubled (III. CONF. 68). The explanation, cited from Voelcker, is that nitrogenous manures by affording the plants an excess of nitrogenous food retard the ripening of corn crops, whereas phosphate of lime, often present in considerable quantity after a mangold crop, has a tendency to induce early maturity (III. CONF. 67).

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This acceleration of ripening helps to save the crop from rust (SUB-CONF. J. 15).

A year earlier, however, Mr. Lowrie had found experimentally that both phosphatic and nitrogenous mixtures decidedly increased the tendency to rust (II. CONF. 50), while the experimental results recorded from Victoria in two successive seasons showed pretty conclusively that plots where wheat was grown with phosphates were more rusty than those grown without phosphates or without manure at all. At the same time the use of nitrogenous manures did not appreciably increase the amount of rust (II. CONF. 7; III. CONF. 42). The explanation given by Mr. Pearson (Victoria) of these results was that probably the effect was indirect; the thinner, poorer crop resulting from the absence of manures afforded better ventilation to the plants, and the better ventilation of a thin crop *in Australia* favours freedom from rust. If the contention that nitrogenous manures increase rust be a sound one, the result is no doubt due to the unusually thick crop produced (II. CONF. 7).

Mr. Shelton (Queensland) was, however, unconvinced by the Victoria results, since in Queensland plots that had received no fertilizing agent were just as variable in their results as those that had been fertilized (II. CONF. 28).

In New South Wales it is believed by some that wheat should never be sown in freshly-manured ground (II. CONF. 33), and in South Australia some are convinced that if the rainfall be light, the more manure is put in the ground the worse will be the crop (III. CONF. 67).

Mr. Farrer (New South Wales) insists on the necessity for securing a variety of wheat that shall be productive in soil of average fertility without the use of manure (II. CONF. 44). Mr. Pearson (Victoria) while agreeing that it was not necessary to manure unless it would pay, pointed out that in Victoria it paid to manure barleys, and to overlook the necessity for manuring wheats would be a mistake (II. CONF. 45).

Mr. Shelton (Queensland) does not believe that the Queensland farmer can afford to manure a wheat-field. In America where the conditions are similar, no one manures directly. They manure indirectly by pasturing, by maize, or by green-crops, giving the manure to the crop preceding the wheat and so "taking the edge off" the manure (II. CONF. 45).

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Disinfection of soil.

§ 27. Several special preventive applications have been tried. Thus "limeing" was experimentally tested in Victoria in 1890 and the following season. In both cases it was ineffectual (II. Conf. 7, 21; III. Conf. 46); on the contrary, it caused a rather heavier flag and thus increased the liability to rust. In Queensland, on the other hand, it was rather favourably reported on (II. Conf. 30).

Potash salts appeared to decrease the rustiness when used in the form of chloride (II. Conf. 7; III. Conf. 46). As nitrate it seemed to toughen the straw and to force the growth of the plant, but as there was little rust about, the experiment was inconclusive (II. Conf. 21).

Common salt and sulphate of iron appeared in Victoria to have an antiseptic property and diminished rust. At the same time they diminished the outturn of grain (II. Conf. 7; III. Conf. 46). In another series of experiments the plots treated with salt were decidedly the cleanest (II. Conf. 14). The result is probably due to the salt stunting the growth of the plants, toughening their straw and checking the tendency to flagginess (II. Conf. 21).

In Queensland, too, salt applied broadcast at the rate of 300℔ [per acre?] is said to have often given favourable results (II. Conf. 30). But the experience of South Australia is that neither kainit nor salt have any preventive effect (II. Conf. 50), and in Victoria renewed experiment showed that, while salt strengthened the crop, it did not lessen rust (III. Conf. 15).

Sulphate of ammonia and superphosphate of lime, one part to three, recommended as a rust-preventing manure, was found to increase the yield, but did not diminish the rust (III. Conf. 15), and in New Zealand *á propos* of a series of experiments with a so-called "preventive" manure sent to Wellington from Australia, Mr. Bayne, Director of Lincoln College, finds that "no manure has yet been discovered that is a preventive of rust in cereal crops" (Sub-conf. O. 494).

Disinfection of Seed.

§ 28. The treatment by disinfectants of the seed to be sown was at first supposed likely to be useful (I. Conf. 53) and has been fully tested. The substances employed have been sulphate of copper, carbolic acid and hot water.

Sulphate of copper did nothing to prevent rust (II. Conf. 14, 46; III. Conf. 15, 21), on the contrary it was considered in New South Wales to have diminished the germinating power of the wheat (II. Conf. 32).

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Carbolic acid was a failure; there was a greater loss from 'Smut' after its use than the observer had ever experienced (II. CONF. 21). This is interesting, because the pickling process, with sulphate of copper at all events, though not efficacious against rust, is good for preventing 'Smut' (II. CONF. 36).

The hot-water treatment, which is said to have been found efficacious in Denmark, was recommended (III. CONF. 68), but found useless (SUB-CONF. J. 15).

No process of pickling can be expected to be useful, for though a few spores may be entangled in the "brush" and the application might destroy these, there is no mycelium in the seed. Rust does not often affect the seed at all and has never been known to enter the seed while in the ground and before the appearance of the leaves. It may and does attack the plant at any stage after it has appeared above the surface of the ground; this, so far as is known, is the only way in which it does attack the plant. No treatment of the seed can, therefore, be of the faintest use (COBB, CONTRIB. vol. III., p. 183). The actual demonstration of this fact is recorded (IV. CONF. 29).

The subject has received very careful attention in Victoria. Twenty different modes of treatment were adopted and the result was to show "that the treatment of seed for rust is a delusion." The hot-water treatment was not more successful than the others. It appeared rather to hasten germination though the proportion of seeds to germinate was lessened, and the ripening was somewhat retarded (IV. CONF. 25).

The view that any treatment of the seed is valueless was adopted as an undoubted conclusion at the last Conference (V. CONF. 3).

Use of mouldy seed.

§ 29. The use of seed that has by accident become mouldy has been advanced as a possible cause of rust. This question has been settled by experimental sowings in South Australia which show that sound dry wheat-grain does not resist rust, while mildewed wheat does not prove more liable to rust than dry grain (II. CONF. 46).

Use of rust-shrivelled seed.

§ 30. The fact that the sowing of rust-shrivelled wheat is not attended by any inherent bad consequences has been long known. The famous breeder, Mr. Jethro Tull, wrote, in 1751, that "some have thought that a large grain of wheat would produce a larger plant than a small grain, but I have full experience to the contrary. Farmers in general know this and choose the thinnest, smallest-grained wheat for seed, and

therefore prefer that which is blighted and lodged." And Sir Joseph Banks in 1806 noticed that rust-shrivelled wheat may be employed for seed. Doubts have been thrown on this experience, however, and the Australian results and conclusions are consequently of very considerable value.

In Victoria it was found experimentally (Port Fairy) that the healthy seed gave the better outturn, but that there was no clear evidence that the liability to rust was less with healthy than with shrivelled grain (II. Conf. 8). In the following season the Port Fairy farm showed that the yield from rust-shrivelled seed was only 7½ bushels per acre, as compared with 13½ bushels from healthy seed (III. Conf. 47). At another experimental station (Dookie), it was found that the yield per acre from rust-shrivelled seed was about 20 per cent. greater than from healthy seed, and the sample was also of superior quality; but that the plants raised from shrivelled seed were perceptibly more rusty than those raised from plump seed (II. Conf. 13).

The latter experience is more in accordance with what is at all events the general belief. The vast majority of Victorian farmers have found the product of rust-shrivelled seed to be at least equal to that of plump seed in quality and yield. If the rustiness of the resulting crop be taken into consideration, it seems to be much the same in either case. Many indeed state that they have never seen a rusty crop from rusty seed; these are probably observers who have not had the misfortune to experience two consecutive rusty years, for when one rusty year follows another, rust attacks both sorts equally (II. Conf. 21). The second generation of the rust-shrivelled seed when sown yielded good crops, but just like the original stock; when rust was present it was affected precisely as the crops from other sorts were (II. Conf. 20). The general opinion in Victoria is, or was, that rusted is quite as good as plump grain (III Conf. 20).

In South Australia it is considered that there is evidently no disadvantage in using rust-shrivelled seed; indeed, if the evidence leans to any side it is in favour of using rusted seed (II, Conf. 51).

In New South Wales the opinion expressed by 17 farmers in 1890 was in favour of plump seed as rust-resisting, only 5 favoured shrivelled seed, and 14 were indifferent. Some of those who sowed rust-shrivelled seed claimed a heavier outturn from it (II. Conf. 32). Dr. Cobb, however, says shrivelled seed is as good as plump so far as mere germination and outturn are concerned, though he favours plump seed (II. Conf. 35);

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and in the following year it is said that the general conclusion in New South Wales was that rust-shrivelled grain is not worse than plump grain.

In Queensland, of 60 farmers who used rust-shrivelled wheat, 55 reported having obtained excellent results, and the others only objected on theoretical grounds (II. Conf. 28).

Mr. McAlpine (Victoria) finds that the germinating power of rust-shrivelled seed is sometimes inferior and sometimes superior to that of plump seed, but, generally speaking, rust-shrivelled germinates just as well as plump. The liability to rust was equally great *in the same variety of wheat* whether the crop was raised from rust-shrivelled or from plump grain. The yield from an equal number of rust-shrivelled grains was, however, superior. These results confirm the general opinion of farmers, which is that rust-shrivelled seed may be safely sown, especially if the land be in good condition and the season favourable for giving the seed a good start. They also confirm the results obtained at the experimental station, Minnesota, U. S. A., where shrivelled seed with careful cleaning and winnowing was found to be safely usable (Sub-conf. L. 22). Even if no harm results from using rusty seed, showing that the disease is in no way of a hereditary nature, necessarily no particular benefit is to be derived from the use of rusty seed since it is not rendered in any way immune against rust, even in the first generation (II. Conf. 21).

Mr. Pearson (Victoria) discussing the subject points out that if it be a question of using plump seed of a crop that has merely "escaped" rust in the preceding year, or of using shrivelled seed of a crop that has been rusty, there is little to choose between them. But if it be a question of using seed whose plumpness is due either, (1) to the plant, though exposed to all the risks of rust infection, resisting these; or (2) to the plant, though infected, still having the constitutional ability to make a fairly plump seed, then it is better to choose such a plump, or fairly plump, seed than to select shrivelled seed. For when the plumpness of the grain is due to constitutional causes in the parent plant, that grain or seed is very much superior to shrivelled grain and ought always to be sown in preference. When, on the other hand, the plumpness is due merely to external conditions of growth, the superiority of such seed over rust-shrivelled seed is not so great, and may at times not be apparent at all (III. Conf. 57).

Mr. Shelton (Queensland) puts the same argument in a somewhat different way. The variety and the time of seeding,

not the quality of the sample of speed, determine the ability of the crop to escape rust-contagion. There is a cogent reason for avoiding seed that bears the marks of the disease; the very fact that the seed has thus suffered from rust is proof that it belongs to a rust-liable variety, and so may be expected to produce a crop strongly susceptible to rust-infection (SUB-CONF. J. 15).

Mr. McAlpine (Victoria) expresses a similar opinion. The rust-shrivelled grain is certainly *not more liable, per se,* to propagate rust in a rusty season. But in selecting seed *for the production of rust-resisting varieties,* one would naturally choose seed with a clean record and as far as possible without the taint of the disease (SUB-CONF. L. 22).

The final report of the Committee at the most recent of the inter-colonial conferences forcibly endorses this opinion, which it puts forward as one of two conclusions at which the conference has arrived, *viz.*: — "that the notion that rust-shrivelled seed can be sown with as good results as plump seed is erroneous" (V. CONF. 3).

A rust-shrivelled grain is hard, dry, generally uninjured in threshing, and contains more gluten and less starch than ordinary grain; in testing the germinating power of the two, Mr. McAlpine found that 87 per cent of shrivelled grain germinated as against only 67 per cent. of plump (SUB-CONF. L. 22). [No doubt the excess is partly to be explained by the diminished liability to physical injury in the case of shrivelled grain. At the same time the presence of starch *in such excess as to cause the grain to be plump* may be a condition as unnatural as the presence, in excess, of fat in the liver of a Strassburg goose; anything therefore, like an attack of rust, that tends to reduce the amount of starch would tend, *pari passu,* to render the wheat-grain less unnatural and, consequently, physiologically more vigorous. This, however, to be an unmixed benefit, would imply that the effects of rust were limited to the prevention of excessive formation of starch; as we know, the effects of a severe attack of rust often lead to the inability of the plant to form a grain at all.]

In Mr. McAlpine's experiment, however, the plump grain in question was the product of the rust-shrivelled seed and the latter was therefore a year older. Commenting on this experiment Professor Sorauer concludes that the germinating power of rust-shrivelled grain is improved when the seed is a year old, an aspect of the question that had not occurred to Mr. McAlpine who, however, is now inclined to think that

the germinating power of all seed is increased by keeping it till it is one year old. At any rate many farmers think so; some even suppose that keeping seed for a year tends to lessen the severity of the effects of rust. (SUB-CONF. L. 22). The use of two years' old seed becomes, therefore, one of Mr. McAlpine's recommendations (III. CONF. 21).

Use of special size of seed.

§ 31. The use of a special size of seed of any variety, though this selection has no bearing on the question of immunity from rust, has been incidentally dealt with.

In all cases small seeds should be avoided as they yield a decidedly lighter crop. In some cases likewise the largest should be excluded as these also yield a crop lighter than average though less light than that yielded by the smallest seeds.

From the largest heads the yield is much the most prolific. The yield indeed is far greater from the smallest seeds of large heads than from the largest seeds of small heads. There seems, however, to be no special benefit obtained by selecting seed from any special part (middle or upper or lower third) of the head (III. CONF. 57).

Supposed Heredity of Rust.

§ 32. The experience obtained during the enquiry into the question of rust-shrivelled grain has, in the opinion of Australian observers, quite satisfactorily disposed of the belief that Rust is a hereditary disease. What is hereditary is a liability to affection in certain varieties of wheat; unfortunately this susceptibility is not confined to such varieties; for breeds of wheat that prove fairly rust-resisting in certain countries or districts fail to escape when sown elsewhere, and wheats that escape rust in one district during a certain season may suffer most in the same district during another (I. CONF. 53). A careful perusal of the latest expression of European opinion (APPENDIX A.) will, however, show that the point is by no means definitely settled; on the contrary, it is probable that the older view, expressed by W. G. Smith and others (*Queensland, Dept. of Agricult.; Report on Insect and Fungus Pests*, n. 1, 1889, p. 210; *Gardeners Chronicle*, 1885, ii, 21) is correct, and that rust is hereditary. The explanation of the fact that is offered by Mr. Smith is, however, certainly insufficient.

Disinfection of standing crop.

§ 33. The treatment of the growing crop for the palliation or prevention of rust, though at first it seemed a hopeful line of experiment (I. CONF. 63), has proved useless.

The effect of spraying with common salt was *nil* as regards diminution of rust; it, however, materially decreased the

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outturn of grain (II. CONF. 7) when the experiment was tried at the Port Fairy Farm, 1889-90. Spraying with sulphate of iron at this farm both lessened the quantity of rust and increased the outturn of grain. It was computed that with a suitable spraying instrument the substance might be applied at a cost of one penny per acre. The result is stated to have been that for 4*s*. 6*d*. spent in spraying with sulphate of iron, six additional bushes of wheat were obtained.

At the Childer's Farm similar experiments seemed to show that sulphate of iron protected the wheat subjected to the spray, for about a fortnight. It was even claimed that the spraying *cures* rust. The period of risk is not perhaps more than a month to six weeks; three sprayings during this period should, therefore, effectually save the crop. The cost should be, at the outside, 1*s*. 6*d*. per acre; and the application need only be made in rusty years (II. CONF. 13). In Victoria, therefore, spraying with a suitable solution was strongly recommended (II. CONF. 21).

Dr. Cobb (New South Wales) favoured spraying on theoretical grounds on account of its having proved effective in peach-rust and other blights (II. CONF. 31), and in 1891 he believed that he had settled beyond doubt his ability to recommend a solution to be used with the strawsonizer which will kill the spores of rust (II. CONF. 35). The bloom of wheat prevents any but the finest spray affecting it, hence the rust may be wetted more readily than the wheat. "Saccharate of copper," or bluestone and treacle, as used in France, was considered by Cobb likely to prove useful, the treacle causing the fungicide to remain on the plant (II. CONF. 36).

In the discussion on this subject at the Second Conference Mr. Pearson (Victoria) considered the strawsonizer unlikely to give spray fine enough, though he deemed spray likely to be of use. Mr. Shelton (Queensland), while not disputing the theoretical value of spray, thought that a new race of farmers would have to be bred before the remedy could be applied. And he asked for caution in recommending spray, first because of the many sprays recommended that prove in time to be valueless, and again because, supposing the sprays to be effective they could not be got upon the plants (II. CONF. 38).

It was pointed out that, so far as the experiments went, they showed that spray applied before rust begins does no good; the answer was that "Saccharate of copper solution" meets the difficulty, because it stays on the plant (II. CONF. 38). Mr. Pearson insisted that spraying should only be

regarded as an expedient of a temporary nature, pending the production of rust-resisting or rust-avoiding varieties, and to this Mr. McAlpine (Victoria) agreed, but urged their use till such time as a rust-free wheat is evolved (II. Conf. 44, 45).

In the next year's experiments it was found that, while spraying with sulphate of copper temporarily cleaned the straw, it got rusty again later on (III. Conf. 15).

At Port Fairy the experiments with sulphate of iron were repeated in 1891. The spraying did appear to kill the rust in the plants to which it was applied, but the rust re-appeared and the beneficial effects were masked or lost. As good results as any were obtained by using 2 oz. of sulphate of iron to the gallon and applying 30 gallons of this solution per acre. There seemed no advantage in exceeding 30 gallons, whatever the strength, even with a dense crop 5½ feet high.

The experiments were deemed a partial success; but for the best results a steam-spray was considered essential (III. Conf. 46). Indeed in Victoria generally spraying with sulphate of iron was supposed to be a decided success (III. Conf. 21).

At the Adelaide Conference of 1892, however, Dr. Cobb thought it doubtful if spraying was worth going on with. If employed it should be as short, quick sprayings, so that the water should remain divided and not run into drops (III. Conf. 29).

In Queensland the experience of 1891 was that spraying "counts for nothing" (II. Conf. 61), and the South Australian experience was just as disappointing (II. Conf. 24, 66). At the later conferences the matter was not even discussed.

Time of sowing.

§ 34. The time of sowing appears to be of the highest consequence, in Australia, in connection with the rust-problem. The comparative absence of rust from self-sown wheat, which is always early, is used as an argument in favour of early sowing (II. Conf. 21), but as it is at least doubtful if such wheat be less rusted (Sub-conf. J. 15; III. Conf. 20), the argument fails.

Early sowing has been the remedy most in favour from the outset (I. Conf. 63). It is found that early sowing greatly diminishes the degree of rustiness: it diminishes the outturn, however, at the same time, for the effect of sowing a fortnight too early has decreased the outturn as much as 33 per cent., though at the same time it ensured freedom from rust. Late sowing increases the risk of rust very greatly; wheat sown a fortnight too late had a much diminished outturn, and was at

the same time badly rusted. Sowing too soon is, therefore, a safer mistake than sowing too late (II. Conf. 10). Early sowing is generally acknowledged to be best, as by that means the crop has a greater chance of avoiding the rust or of coping with it if attacked. This is repeated again and again in the Australian literature of rust (II. Conf. 25, 28, 30, 32, 33, 35, 44, 45, 50; III. Conf. 14, 20, 22; Sub-conf. J. 14; O. 495).

An interesting instance, as bearing out the same rule, is quoted from one of the Victorian experimental farms (Dookie) where a recently imported English variety produced a thick crop late of maturing and was very rusty (II. Conf. 14). The same was the experience with 12 freely tillering Swedish wheats, specially imported because in Sweden they are rust-resistant (IV Conf. 21). The beneficial effects of early sowing were very marked at another of these farms (Port Fairy) in 1891, and the more so because rust in that year came on very early. The difference of outturn between wheat sown on May 27 and June 4 was 8 bushels per acre, on May 27 and July 15 was 18 bushels per acre in favour of the earlier sown (III. Conf. 48).

The middle of April to the middle of May is given as the time for sowing in Queensland, the precise date depending on the weather (II. Conf. 28). In New South Wales May is late for sowing and any subsequent month is too late to sow to escape rust (II Conf. 32). In South Australia wheat cannot be profitably sown after May, and land sown with wheat in June or July would be more profitably cultivated if laid down in some other crop (II Conf. 50).

If, however, early sowing be a good general rule, there are exceptions to it (II Conf. 50; Cobb, Contrib. vol III. p. 183). One danger is that a late frost may pinch the wheat while in bloom (II Conf. 98). Another is that muggy weather may set in about the time the wheat of the early sown crop is in flower and thus favour the development of rust which the later sown might escape or be little affected by. Thus in Victoria in 1889 whereas early sown crops only suffered to the extent of 4 bushels per acre while late crops lost 8 bushels, in 1887 the early sown suffered most (II Conf. 16). It would appear indeed that in nearly all the years given as "rusty years" for Australia the early sown wheat suffered badly (IV Conf. 20).

On the whole, however, early sowing is the safest rule; but it is mainly of value when associated with the selection of early maturing varieties (II. Conf. 16, 33).

FUNGI. | **Rust and Mode of Sowing.**

Mr. Farrer, the great authority on wheat-breeding, insists strongly on the advantages of early sowing for all wheats, whether they be late or early of maturing. The influence goes beyond the effect it has in making them ripen sooner. If two wheats, equally liable to rust, be sown, the one an early and the other a late variety, and the early variety is sown late, while the late variety is sown early, Mr. Farrer's experience leads him to think that although the late-sown early variety may ripen before the early-sown late variety, it will be more liable to rust than the other (II. CONF. 44, *note*).

Mode of sowing.

§ 35. As might be expected it makes no difference to the liability to rust either way, whether the wheat be drilled or sown broadcast (II. CONF. 19, 51).

Thin-sowing as opposed to thick is favoured in Australia on theoretical and on practical grounds. Newly imported thick-growing sorts are apt to be much rusted (II. CONF. 14), as are rank and flaggy crops on rich or virgin soil (II. CONF. 19). Any lodged portion of the crop is similarly affected (II. CONF. 22). Actual thick-sowing is found by the majority of Australian farmers to cause greater liability to rust. This is the experience in Victoria (II. CONF. 19); in New South Wales (II. CONF. 32; III. CONF. 10); in South Australia (II. CONF. 49, 51). In Queensland opinions differ greatly (II CONF. 28). Nevertheless there is a preponderance of opinion in favour of thin-sowing everywhere throughout the Colonies and it is recommended by the conferences (II. CONF. 28, 30, 32, 51; III. CONF. 14, 20; SUB-CONF. J. 14). In Queensland a thicker seeding is recommended in forest land as the soil there is less rich.

The experience in Canada and in England is the reverse of the Australian; in these countries thick growing crops are less rusted than thin (II. CONF. 7, 19). There the greater coolness due to ventilation may be counterbalanced by the greater warmth due to better penetration of the sun's rays (II. CONF. 7). In Australia the thin-growing crops are possibly cooler, from the greater evaporation due to better ventilation, than thick-growing crops are. Besides, thick-sown wheat comes up heavy and rank, and the flag exposes a larger surface to infection, at the same time it renders the access of sunshine to the flag impossible, and thus diminishes the resisting vigour of the leaves (II. CONF. 34). For this reason, besides merely sowing the crop thinly, it is advisable to select varieties of spare habit, upright in growth and lightly flagged.

Changes of seed.

§ 36. Besides sowing on a dry seed-bed Mr. McAlpine in his summary of recommendations advises thin and early

sowing of two years' old seed, changed frequently from a colder climate (III. Conf. 21), this being considered, as a rule, most satisfactory. But local conditions are said to modify the last statement as a general conclusion (II. Conf. 14, 33), and Mr. Lowrie is of opinion that when the change of seed is from a colder to a hotter climate, the susceptibility to rust is increased. It has at all events always been so in the case of wheat introduced to Australia from England, America and New Zealand (II. Conf. 50). The same has been the experience with Swedish wheats reputed to be rust-resistant, in certain instances these proved complete failures; in the worst cases, however, "the samples were rather late in being sent for sowing as early as the district requires" (IV. Conf. 27).

Nor has the opposite experience, sowing seed from a hotter climate, been altogether satisfactory. In Queensland reference is made by the Honourable Mr. Macansh to a wheat originally received from India that had been grown on Canning Downs for 8 years up to 1892, and had never been rusted; also to another very early Indian kind grown for 3 years up to 1892 that had never shown any rust even on the flag (Sub-conf. J. 22). The conditions in Queensland are perhaps more like those in India; in Victoria, however, the experience with Indian wheats was very poor indeed; the particular kind tried was a race named *Pissi* received from the Central Provinces (Sub-conf. L. 18). Now *Mundia pisi* chances to be one of the kinds reported by the Chief Commissioner to have some power of resistance against rust (*Resol. Rev. Adm., C. P.*, 1894-95, p. 2); as a set-off it may be noted that cross-bred wheats from Australia, supposed to be rust-resistant, fell victims to rust in the Central Provinces in a year when rust was not prevalent; it must be noted, however, that the crop had to be subjected to conditions as regards irrigation that are found to be unfavourable in Australia (*Rep. by Comm. of Settlements and Agric., C. P., on cross-bred wheat*, 1897).

Time of reaping.

§ 37. To save a crop attacked by rust it has been recommended that it should be cut in the 'dough'-stage; that is, before the crop is ripe, and while the grain is still soft, though no longer fluid in the centre as it is in the still earlier 'milk'-stage.

In Victoria official experiments seemed to show that grain from wheat cut in the dough-stage was superior to grain from wheat cut when ripe; the yield per acre in 1890 was, however, slightly less (II Conf. 10). In 1891, the wheat cut in he dough-stage yielded 38·7 bushels per acre, that which was

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Rust and Time of Reaping.

cut ripe only 33·3 bushels; this, however, it is admitted, may partly be accounted for by accidental variations (III. CONF. 48). The general farming opinion, in 1891, seemed slightly in favour of reaping in the dough-stage in Victoria (III. CONF. 18).

In New South Wales the matter is considered debateable. In 1890 (II. CONF. 32), the practice was supposed to be generally favoured, because it not only saves waste of grain from shedding out, but also arrests the ravages of rust if the crop be only slightly diseased. But, to take full advantage of the practice, early maturing varieties of wheat must be secured.

Mr. Farrer (New South Wales), dealing with this matter at the Second Conference, said that reaping in the dough-stage possesses so many advantages both for millers and for growers that its recommendation is not astonishing. But it is not desirable *at all times*, and is particularly undesirable in the case of grain to be used as seed. Mr. Farrer's statements are given on the authority of Professor Blount, who finds that, when grain is picked in the dough-stage the germinating power is greater and the growth more vigorous but the grain after such an operation is *not so good* for seed. All seed-grain should be perfectly ripe when picked. No explanation has been given why seed picked in the dough stage should grow more vigorously, but for a single season it certainly does so; after that, deterioration is fatal and rapid. For milling, on the other hand, it is better to cut in the dough-stage, on the principle that grass is cut before going into seed as it is then more nutritious.

Mr. Farrer is strongly of opinion that much of the deterioration—the "running out"—that takes place in the majority, if not all, the "standard" varieties of wheat can be traced to the practice of harvesting seed while still immature. And he urges that grain to be used as seed should not be reaped in the dough-stage (II. CONF. 41). This recommendation was adopted by the Second Conference (II. CONF. 52).

In 1891, however, it appeared that farming opinion was divided as to the benefit to be got from reaping even the rusted crop in the dough stage (III. CONF. 15); Mr. Farrer, moreover, insisted that it had now been satisfactorily proved that it was more profitable to allow wheat to become ripe before harvesting it (III. CONF. 36).

The experience of thirty-three Queensland farmers is given in connection with this point. Eleven got good grain, twelve got pinched and shrivelled grain, ten got worthless grain

(II. Conf. 28). Mr. Shelton (Queensland) explained that as regards maize he had shown by experiment that in reaping at all stages of ripeness,—milk-stage, dough-stage, and dead-ripe—there is a progressive increase in yield the later the stage; each day later shows a difference in favour of the result, the total difference from earliest to latest being one of 8 bushels yield per acre. But what seemed true of maize was not, of necessity, true of wheat (II. Conf. 45); if reaping in the dough-stage be satisfactory, in wheat it is doubly advantageous, since wheat cut then is understood to give better flour (II. Conf. 38). In any case reaping in the dough-stage is to be recommended in preference to indiscriminate cutting as hay in the milk-stage, which is a very common practice in Queensland if rust appears on the plant during that period (II. Conf. 30), and which is sometimes adopted in Victoria (II. Conf. 22) also.

Mr. Inglis (South Australia) instanced a case where some wheat cut very early had a nice small grain, whereas what was left in the paddock all went to powder (II. Conf. 45). This corroborates the advantage claimed for reaping before ripeness; on the other hand, Mr. Kelly (South Australia) mentioned a case where a field of 400 acres tried by the reaper did not produce any grain. Sheep were, therefore, turned on till, in July or August, the plants were allowed to grow; the ultimate result was that the field yielded 15 bushels an acre (II. Conf. 35).

Professor Lowrie has given very interesting and useful evidence on this point. In South Australia the stripper is largely used, for this reason the wheat must be permitted to become dead ripe. If cut in the dough-stage the grain shrivels less from rust, but the advantage gained was less than might have been expected. In 1890, in five cases where equal blocks of wheat were laid off in pairs and one block of each pair was cut early and threshed, the other of each pair allowed to become dead ripe and then stripped, it was found that, in four cases out of the five, more wheat was got from the stripped than from the threshed blocks though the sample was about 2lb per bushel lighter (II. Conf. 50).

Repeating his investigations in 1891, Mr. Lowrie found that cutting with the binder in the dough-stage and threshing afterwards, the yield was 12 bushels 10lb per acre; cutting nine days later the yield was 11 bushels 10lb. The same wheat stripped gave 10 bushels 28lb; the result was, therefore, slightly in favour of the binder with subsequent threshing, and slightly

FUNGI.	Resumé of Recommendations.

in favour of cutting in the dough-stage. The previous year the result was slightly in favour of the stripper.

Stripping is in favour in South Australia because the yields are so light and threshing is so costly; if the yield be under 15 bushels an acre the stripper is the more economical machine; with higher yields it would be advantageous to use a binder and thresher, and thus get straw as well as grain (III. Conf. 66).

In 1894, the Fourth Conference only recommended the harvesting of rust-infected crops in the early or dough stage (IV. Conf. 48), and the subject is not dealt with in the Committee Report of the Fifth Conference.

Resumé.

§ 38. Reviewing briefly the proposals for the prevention of Rust, it may be said that drainage *per se* is not a palliative, nor is irrigation *per se* an excitant; it seems to be on the whole advisable to sow in a dry seed-bed. Rotation of crops appears to be advisable for practical reasons as well as on theoretical grounds; a thin crop is advisable in Australia, as it probably also is in India, although the experience of cold countries is the reverse to some extent: a comparatively poor soil also is preferable to a rich or heavily manured soil; this, for the very reasons that prevail in Australia, is probably true of India also. Treatment of the soil with special preparations is a mere throwing away of time and money; the disinfection of the seed before sowing and the disinfection of the growing crop are equally valueless. The use of rust-shrivelled seed is not *per se* a cause of rust, but it is to be avoided because the fact that it is rust-shrivelled indicates that it belongs to a rust-liable stock. The one great palliative is early sowing.

The reaping of wheat before the seed is fully ripe yields a grain that finds favour in certain markets, but is not a course to be adopted at all where the grain is to be used for seed and is not an act to be recommended except in the case of a rusted crop.

The most rational treatment is put briefly and clearly by Mr. Bayne, Director of Lincoln College, New Zealand (Sub-conf. O. 494):—Clean culture, judicious rotations, fallowing of lands, sowing early, and selecting accredited rust-resisting varieties of seed. The last recommendation is that which is most hopeful, since it attempts to eliminate the factor of inherent susceptibility. The history of the efforts of Australian wheat growers in this direction forms the subject of the concluding chapter.

CHAPTER IV.—RUST-AVOIDANCE.

The best remedy for rust.

§ 39. At the Second Conferenee Mr. Farrer (New South Wales) expressed the opinion that the best method of combatting rust is to secure or create resistant varieties with the characters demanded by the special requirements of Australia, and possessing, together with high milling qualities, such powers of resistance to the pest as to give them value on that account (II. CONF. 39).

Wheats reputed Rust-proof.

§ 40. That certain wheats, under what appear to be identical local conditions, escape rust in particular seasons and in particular localities is well-known, and the selection of these wheats is strongly recommended (I. CONF. 43; II. CONF. 22, 39; SUB-CONF. J. 22; O. 494).

It is said that practically rust-proof wheats exist in the Bombay Presidency, and in Japan also it is said that practically no rust exists. A set of wheats have been evolved in Japan that do not exceed 20—24 inches in height, with straw so stiff and strong as to stand the severest storms. These stiff strong-stemmed sorts are just the kinds likely to resist rust. It is, Mr. Shelton (Queensland) thinks, not improbable that rusty regions may have become practically rustless by the selection of rust-free kinds. For Japan, at least, with its practice of irrigation and its free use of nitrogenous manures, with its mild climate and its excessive humidity, the climate and conditions are all those that are most favourable otherwise to the development of rust (III. CONF. 62).

However, the escape of a wheat from rust in one season is no proof that it is rust-resisting (II. CONF. 36, 50). Many wheats also that seem rust-resistant in one locality fall victims to it in another; *e.g.*, a wheat that is rust-proof in a maritime district may be badly rusted inland, and *vice versâ* (II. CONF. 9; III. CONF. 36), and it is admitted that such a thing as a rust-proof wheat does not exist (II CONF. 30; III. CONF. 22, 28; SUB-CONF. L. 15).

Proof against rust *versus* poor outturn.

§ 41. The question has arisen whether it is advisable to sow a wheat that has the reputation of being able to resist or escape rust, or to presume that the season is not to be a rusty one and to sow a wheat that, though notoriously subject to rust, possesses other qualities that render it the more desirable of the two.

Thus, freedom from rust and prolific yielding are said rarely to go together, and if the two qualities are found to be incompatible, one Victoria delegate urges that the latter

FUNGI. | **Classification of Wheats.**

quality must be preferred. It is better to run the risk of an occasional bad year than to always have a meagre outturn. If they are not incompatible, and the evidence advanced does not go to prove incompatibility, it is open to select from, and improve upon, tried rust-resisting varieties, or to select from known prolific yielders rust-resisting strains (II. CONF. 9).

Mr. Shelton (Queensland), however, strongly deprecated the cultivation of risky sorts that fetched a penny or so per bushel more when there were many varieties in existence better able to withstand rust (II. CONF. 45). A South Australian delegate, too, was of opinion that farmers should always grow a proportion of these rust-resistant wheats to avoid a total collapse of the wheat crop in any year (II CONF. 50). In any case it is admitted that sorts which are poor yielders in one district are prolific in another (II. CONF. 9).

Classification of wheats with reference to rust.

§ 42. From the point of view of their resistance to rust Dr. Cobb gives the following classification of wheats :—

(1) *Rust-proof Wheat.*—A wheat that will not permit the mycelium of any rust to enter and feed on its tissues. No such wheat is known to exist, but the term is convenient for purposes of comparison.

(2) *Rust-resistant Wheat.*—A wheat that under conditions favourable to its growth resists at all seasons of the year the entrance of the rust-mycelium into its tissues, or if the mycelium of rust has found admission, resists its subsequent growth and development. A number of such wheats are known, and from this class selection of existing or creation of new varieties should take place.

(3) *Rust-liable Wheat.*—A wheat the opposite of rust-resistant. Most wheats are of this class; and should be avoided or, if retained, hardened by cross-breeding with rust-resistant kinds.

(4) *Rust-escaping Wheat.*—A wheat that, if sown at the proper time, matures its grain so quickly as to be ready for harvest before the rust of an ordinary season can prevent a paying crop (III. CONF. 28).

Earliness of crop.

§ 43. One of the leading characters of rust-resistant wheats is that of ripening early, and this is consequently given as a character to be attended to (II. CONF. 25, 50; III. CONF. 45). However, the earliest wheats are apt to "shell," and this is a feature that must be eliminated by selection from any such

wheat, adopted as a rust-resisting or rust-escaping sort (III. CONF. 38); the chaff should hold the grain firmly and well (III. CONF. 36). According to Mr. Farrer, too, early maturity does not of itself enable a wheat to resist contagion; all it does is to ensure that it is beyond the susceptible stage before contagion is abroad (II. CONF. 43). Many of the varieties reputed to be rust-resisting are nothing of the kind; they are only early-maturing kinds that therefore often escape. If such kinds chance to be late, or if rusty weather comes on early, they are invariably affected (II. CONF. 43). It is even found that a rust-resisting wheat may (just like a rust-escaping one) succumb to rust if subjected to unfavourable conditions; for example, such kinds, though normally free from rust, may be just as rusty as their neighbours if "lodged" and smothered (III. CONF. 57). Therefore, though earliness is always a property to be aimed at and is desirable in all kinds of wheat, it is not in itself sufficient to ensure safety. Besides, farmers are not always able to sow early (I. CONF. 43; II. CONF. 43) and an early wheat, if sown late, is often just as liable as another kind.

Risk from parching winds and from frost.

§ 44. One advantage of early sowing is that it often leads in northern districts to the escape of the wheat from the hot dry winds that sometimes pinch the grain as much as rust does. On the other hand, early sowing often exposes the wheat in cold and late districts to spring frosts at the time the plants are in bloom (II. CONF. 43), and it is even said that for Victoria one of the essential characters of a good variety of wheat must be that it is a frost-resisting one.

Hardness of grain; Bad milling qualities.

§45. Red wheats and wheats with hard, flinty or wiry straw and hard grain suffer least (II. CONF. 32, 36, 50), and in spite of the fact that they are not so desirable for milling purposes, they should be grown and improved upon. Indeed, Mr. Farrer insists that hard grain, which is in correlation with the hard flinty straw, is far from undesirable. Such wheat can be effectively dealt with by roller mills; it is rich in gluten; the bran is often very thin, and it is much less liable to weevil. For the reasons stated, indeed, hardness might be considered essential (II. CONF. 43).

Mr. Shelton (Queensland), in support of Mr. Farrer's contention, points out that the wheats sent from the north-west of America to feed Europe are small, hard, red wheats that a Queensland farmer would despise. Indeed, when good vigorous rust-resisting varieties of the kind are grown in Queensland, the millers cut these down 2*d.* to 3*d.* a bushel as

FUNGI.	Characters accompanying.

compared with white wheats. Yet these hard, red wheats yield the very best flour, superior in nutritive qualities to anything yielded by white wheats. All that is required is suitable machinery to mill and unprejudiced farmers to grow wheats of the kind (II. CONF. 45).

The South Australian delegates, however, appeared to appreciate more keenly the disadvantages of bad milling properties (II. CONF. 48, 50). It is admitted that in 1890 of 100 sorts experimentally grown, only one variety was quite free from rust—an African wheat with large flinty grain and solid straw; this, however, was no sufficient reason for supposing it absolutely rust-resisting. These bad milling kinds should be avoided if better are available, and Mr. Farrer includes the possession of high milling qualities as essential in any variety secured or created (II. CONF. 39). Indeed, as Mr. Farrer admits, rust-resisting wheats have come to be looked on with suspicion in Australia, because of their bad milling properties. The association is, he thinks, altogether accidental; almost all the varieties of high rust-resisting power are of hot-country origin, and in the countries where these resisting varieties have been evolved, milling qualities have not been an object of search (II. CONF. 43). It is, however, insisted that rust-resistance is not confined to hard wheats (III. CONF. 58; IV. CONF. 11). Indeed when wheats are classified in the ordinary commercial fashion into hard and soft, red and white, so that one gets four main groups;—

(1) Soft pale-straw coloured,
(2) hard yellow,
(3) soft pale-red, and
(4) hard dark-red wheats,

with, of course, intermediates, it becomes apparent that there are rust-resisting varieties in each of the classes and, of the Victorian kinds, 3 out of 4 to which top-prices were assigned, were rust-resisting varieties (III. CONF. 58, 59). One delegate even contends that wheats which are soft in one place are hard in another (IV. CONF. 11).

Spareness of habit.

§ 46. It is recommended that wheats selected should be those that are not too luxuriant of growth and that have little flag (II. CONF. 32); varieties of vigorous growth are not suited to Australia (II. CONF. 43). Besides the greater risk of rust alluded to in a previous chapter, this habit of vigorous growth and "free tillering" is associated, in Australia at all events, with the habit of not properly filling their ears. The habit seems to be natural to certain of these varieties.

The explanation perhaps is that the strength of the plant is largely used up in the formation of extra straw and leaves, and they have not sufficient vital power left for the formation of good grain. The Australian experience is that what are termed "improved English" varieties are most at fault in this respect. They have been selected for a moist soil, well furnished with plant-food in the shape, directly or indirectly, of manure, which thus affords food enough for many stems and their grain. In Australia, where the soil is poorer from constant cropping and where, even if manured, it is, from the dryness, not in a condition to give up the food even if manuring were otherwise economical or practicable, such a variety is to be avoided. This doubtless explains how the varieties most productive in England are the least satisfactory in Australia. Having been improved in the matter of foliage so as to increase the leaf-surface exposed to sunshine and favourable to evaporation they are left with relatively insufficient root-force for food-collection in the poorer and drier Australian conditions (IV. Conf. 17, 18). To judge by the account given of their culture (IV. Conf. 27), this is the case with "improved Swedish" varieties also, and to judge by the detailed table accompanying the *Report* on their cultivation by the Commissioner of Settlements and Agriculture, Central Provinces, the same is to some extent true of "improved Australian" varieties in India.

An exception to the objection against vigorous growth must be made, Mr. Farrer says, in favour of all the strains of "Hard" (*Triticum durum*), and also of some of the strains of "Poulard" (*Triticum turgidum*) wheat. The "Durums" in particular are very resistant and have very wiry straw; the "Poulards" have the same characteristics but less markedly: both mill very badly.

Except "Durums" and "Poulards" and one or two varieties with Durum or Poulard blood, all rust-resistant wheats are of moderate or dwarf habit. This habit, Mr. Farrer thinks, may have been naturally acquired in hot countries by the weeding out of vigorous young plants from exposure to rust. The more scanty the foliage, the more silicon there is in the epidermis and the more rust-resistant is the variety. Besides, dwarf wheats are often more productive (II. Conf. 43).

Absence of beard.

§ 47. Mr. McAlpine found bald wheats largely in the majority as regards rust-resisting power (Sub-conf. L. 15).

FUNGI. | **Rust-resisting Qualities.**

These wheats are advantageous to grow in any case on account of the greater ease with which they may be thrashed.

Size of leaf.

§ 48. Wheats selected should have leaves of stiff, erect habit so as to prevent spores from lodging on the surface (III. CONF. 33, 35). Dr. Cobb further would have the leaves narrow for the same reason and, indeed, would like to see the flag bred off the wheat altogether, letting it rely for nutrition on the sheath alone (III. CONF. 33). To Mr. Farrer this suggestion does not appeal; he fears too great narrowness of leaf must be incompatible with high productiveness, and therefore would not like to see the flag eliminated (III. CONF. 35).

Toughness of cuticle.

§ 49. But the nature of the flag as to uprightness or narrowness is of little moment as these characters only tend to discourage the settlement of spores. The chief character to seek for is a tough cuticle such as accompanies a flinty straw (III. CONF. 33, 35; SUB-CONF. L. 23). The question of trying to breed a wheat with stomata too small to admit the entrance of rust has been raised (II. CONF. 36; III. CONF. 32), but in Dr. Cobb's opinion the truly rust-resisting wheat would be one that, though it lets rust in does not let it come out again, as is the case with the red-skinned hard-stemmed varieties (II. CONF. 36). This does not postulate for these varieties a constitutional ability to resist rust, it merely implies that the cuticle, supposing the fungus has got inside the leaf, prevents it from bursting through and forming *sori* (III. CONF. 35).

Glabrous wheats appear to be most affected by rust, and Dr. Cobb therefore suggests the cultivation of hairy varieties; the hairs probably help to prevent the contact of spores with the epidermis of the plant (II. CONF. 32; III. CONF. 36).

Presence of waxy bloom.

§ 50. Glaucous wheats, or wheats with the leaves covered by a thick waxy bloom, should be selected (III. CONF. 33, 35). The comparative freedom from rust enjoyed by such wheats was first noticed by Dr. Bancroft in 1888 (III. CONF. 57). The waxy bloom assists in two ways; it reduces the size of the stomata, or breathing-pores of the leaf, thus rendering the entrance of rust more difficult even if spores settle on the leaves; it, moreover, renders it difficult for moisture and therefore for spores to rest on the surface of the leaves at all (II. CONF. 35). Mr. McAlpine, however, while agreeing in the abstract with this view, points out that if the bloom does not appear till after the entrance of the spores, it can do no good. He finds that some glaucous wheats are anything but free from rust, while some rust-free wheats are only moderately glaucous (SUB-CONF. L. 23). A year later, however, Mr.

McAlpine came to somewhat different conclusions. Generally speaking those plants which were very glaucous were not so much attacked by rust. On the other hand, those that were absolutely free were only moderately glaucous. The general opinion of farmers, who are often right in these matters, is that glaucousness is a sign of weakness in a plant. It is, however, a question how far the farmer mistakes for glaucousness a pallor due to want of moisture. Mr. Shelton, no doubt correctly, expresses his belief that the blue tinge taken by the farmer for glaucousness often has nothing to do with that character (IV. Conf. 29).

The only difference of opinion between Dr. Cobb and Mr. Farrer would appear to be that, while both consider earliness the first essential, Mr. Farrer would look on glaucousness as the leading physical character to select, Dr. Cobb would primarily select a toughened cuticle.

Constitutional resisting power.

§ 51. Besides the characters so far described, there should be an attempt to select and increase the indefinite quality of "constitutional resisting power." This can be done by the perpetuation of certain old varieties and by the breeding of new ones (II. Conf. 44; III. Conf. 36). These rust-resisting varieties are more likely to be got from young than from old varieties. Such varieties may be obtained by picking out of rusty crops plants that are entirely clean.

Selection of seed.

§ 52. Mere selection of seed from clean or slightly affected plants could at the outside only give temporary results which would continue only so long as equal care is taken in selecting, and could at the outside only produce resistant strains of known varieties. But the resisting quality must soon disappear under continued cultivation. A quality given to a variety by this kind of selection can only be fixed by cross-breeding, so as to make it a normal characteristic of a fixed variety (III. Conf. 44). In fixing such types it would probably be necessary, as in the case of cattle, to intercross three breeds (II. Conf. 47). It is suggested that wheats are weakened by continuous cultivation (II. Conf. 48).

It is of course always possible that a variety so elaborated may only be resistant to one kind of rust. Wheats that seem naturally rust-proof against one often succumb to another, and wheats that have obtained a good reputation and have suddenly been found to fail, may really have had the power of resisting one rust, but may have on the occasion of their failure been attacked by a different one. It is thus needful to have farmers distinguish, if possible, between one rust and another,

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and when they report the fact that a variety has failed, to be able to say which rust did the harm (III. CONF. 44).

Changes in character of varieties of wheat are continually going on. This is well instanced in Australia by the fact that formerly, when hand-reaping prevailed, the object was to grow wheats that ripened gradually—now that reapers and strippers are used the object is to have only evenly ripening kinds (II. CONF. 48).

Practical considerations in selecting seed: Nature of Straw.

§ 53. In selecting wheats that are rust-resisting there may be other faults. They may have poor heads giving a poor outturn, or they may have bearded heads causing difficulty to thresh and clean; they may have thin and loose chaff and thus not hold the grain, a grave fault if the grain has to be harvested in a state of dead ripeness; this point has been already alluded to. Then the cuticle may be hard but the straw be brittle and weak, a grave fault if the crop is liable to be exposed to storms or heavy rain. The habit of suckering from the root and of having tillering shoots spreading horizontally is also to be avoided; the former character leads to uneven ripening of the crop; the latter renders it liable to the same objection as brittleness with reference to storms, and in any case gives a crop that does not stand up well before the reaper or stripper (II. CONF. 44; III. CONF. 35).

Habit.

Another point to be ascertained in selecting seed is that the spareness of habit, a character otherwise indicative of a rust-resistant variety, be not due to constitutional weakness, and it must, moreover, be noted whether the escape from rust has not been due to mere unhealthiness on the part of the plant and to its consequent inability to harbour and nourish the parasite. Such plants are not uncommon; they are betrayed by their pinched ears (III. CONF. 35).

Nature of Bran.

One of the characters that militate against any variety of wheat is the possession of a thick skin and the production of much bran (II. CONF. 48). It should therefore, in selecting varieties, be an object to secure a thin-branned grain, long rather than short or round, small or medium rather than large, with a shallow crease and a rounded but not too prominent germ; a deep furrow is very objectionable as it increases the amount of bran and harbours dirt, a prominent germ gets injured in thrashing (II. CONF. 44). The colour of the grain is immaterial as that is wholly a question of the bran; as it happens, however, Mr. Farrer considers the red wheats best for milling. He also advocates the selection of only hard wheats with a semi-transparent glutinous grain of

fine texture, on the ground that they are most nutritious. This is no doubt true, but the interested "dealer" and the ignorant consumer will probably long insist on the cultivation of the comparatively worthless starchy wheats.

Nature of Chaff.

Exposure to rain after ripening is, even in the unreaped wheat, apt to induce sprouting. This is much diminished in wheats that ripen with drooping heads and that have a close-lying chaff. Such sorts should be selected on this account alone; incidentally too it is to be noted that the closer the chaff lies the thinner is the bran (III. CONF. 44).

Strength of Flour.

Still another character that calls for attention in selecting wheats is the strength of the flour obtained. This, from many points of view, is of the highest importance. When we say that the strength of a wheat=60 we mean that, converted into flour, a sack (200lbs.) of this flour will absorb 60 quarts of water in making a dough fit for baking; if the strength is=45 then a sack (200lbs.) of the flour will absorb only 45 quarts of water. While only 301½lbs. of dough fit for baking can be made from a sack (200lbs.) of Vermont wheat with strength =40·6, as much as 368½lbs. can be made from the same quantity of a variety bred by Mr. Farrer which has a strength =67·4. Assuming—though this assumption is probably only approximately correct—that 5lbs. of dough go to make 4½lbs. of bread, a sack of Vermont flour will only make 271¼lbs. of bread as against 331½lbs. of bread—a difference of 60¼ lbs.—made from the other. This quality, like all other qualities, can be increased by selection and rendered stable by crossbreeding (SUB-CONF. H. 1, 5).

The quality depends (1) on the amount of gluten the grain contains, and (2) the proportion in which constituent glutens—glutenin and gliadin—are associated in the gluten. The gluten-content does not by itself exhibit the strength of the flour, and the determination of the glutenin and gliadin is a tedious process. It is therefore best, Mr. Farrer thinks, from the practical standpoint, to actually mill a weighed quantity of grain, weigh the resulting mill products—flour, pollard and bran, and then make a given quantity—not less than 10lbs.—of the flour into bread, noting the exact amount of water the flour takes up in being made into dough and weighing the baked bread. The flour used must, of course, be the 'straight' flour made from the wheat, not flour that has been divided into different grades. A small roller-mill, capable of dealing with so small a quantity as 10lbs. of grain, has been invented by Prof. Maercker of Halle. It is manufactured by Ganz

& Co. of Buda-Pesth at a cost of £50, and is recommended by Mr. Farrer as a useful possession for an Agricultural Department (SUB-CONF. H. 7).

Resistance to Drought.

Another quality capable of increase by selection is that of withstanding the effects of heat and drought. In seasons of great dryness and scanty rainfall, among heads that are mostly pinched and shrivelled some will be found with plump grains. Such grains should be harvested carefully and sown in soil especially liable to become dry quickly. In this way, Mr. Farrer thinks, it is possible that strains may be developed which might prevent droughts from being so disastrous as they are in India (SUB-CONF. H. 5).

Flavour of grain.

Yet another quality to be attended to in selection is that of good flavour in the grain. Wheat-buyers in Australia attach much importance to the quality. There is every reason, Mr. Farrer thinks, to suppose that this is also an inherited quality. To possess good flavour grain has to be 'well-grown'; pinched or defective grains never possess it. The estimate can only be made by biting and tasting. The point is probably one that is worthy of attention in India, since Mr. Farrer says that, though there are exceptions, Indian wheats are rather deficient in flavour (SUB-CONF. H. 5).

Technique of selection.

§ 54. A detailed account of Mr. Farrer's method of applying the principles laid down in this chapter is contained in a report read by him at the Fourth Inter-Colonial Wheat Conference (IV. CONF. 14). The portion of the Report that describes Mr. Farrer's practice being too technical for condensation is given in full as an appendix (APPENDIX B, i. p. 78) which should be carefully studied by all who undertake wheat-growing experiments in India. In a recent letter (August 1897) to the Secretary to the Government of India, Department of Revenue and Agriculture, Mr. Farrer has added certain hints especially applicable to India; these are also given in full (APPENDIX B, ii. p. 83), and should be equally carefully attended to.

Special varieties.

§ 55. At the various Conferences many different varieties have been mentioned and recommended as rust-resistant, while others have been similarly recommended in Inter-Conference publications. These, it is needless to say, have in many cases ultimately proved susceptible to one or other rust in one or other of the Colonies, and it is significant that the number of varieties recommended as "Rust-Resisting" at the Fifth Conference held last year (APPENDIX C. v.), even with limitations as to districts, is no greater than twelve. Five others

are recommended as "Rust-Escaping," two more as "Prolific and Moderately Resistant."

Indian wheat in Australia and Australian wheat in India.

§ 56. The experience of Australian farmers with Indian wheats has been very favourable in Queensland (SUB-CONF. J. 19, 22; K. 23), but very poor in Victoria (SUB-CONF. L. 18). And the experience with Australian wheats in India has been so far unsatisfactory. It is quite true, as the Commissioner for Settlements and Agriculture, Central Provinces, in his *Report on the Cultivation of Australian Cross-bred Wheats* says, that "the experience of one year is quite insufficient upon which to base an opinion as to the rust-resistant properties of these varieties." But the same officer writes equally justly when he points out that "it is significant that rust appeared in these plants when there was not a trace of it elsewhere in the farm."

Bearing of the Australian experience on Indian Requirements.

§ 57. The opinion of the Director of Land Records and Agriculture, Bombay, is quoted as questioning whether there is any use in attempting the growth of foreign wheats, and as considering that the Indian varieties supply ample material for improvement (*Agricult. Ledger*, 1895, n. 20, p. 71). With the latter opinion the Reporter on Economic Products expresses his entire agreement, and very justly so. The writer is inclined to agree also with the first opinion.

The Chief Commissioner of the Central Provinces points out how within his government there are at least two varieties, *mundia, pisi* and *bansi*, that have a reputation for rust-resistance (*Resol.* on *Rev. Admin.*, C. P., 1894-95, p. 4); there is a variety in the Western Deccan, *bakshi*, with the same reputation (III. CONF. 62), and in Bengal there is a variety *mághi* (so-named from its ripening so early as the month of Mágh), that has been found, as a matter of fact, to escape rust very markedly in the midst of the most unfavourable conditions. There is ample material ready to hand for experiment and action on the lines indicated by the Australian experts.

Everything in the evidence afforded by the Australian literature shows that even within Australia the experiments have required to be local, and that favourable results have, as a rule, only been obtained for limited areas. That this is just as likely to be true of India needs no demonstration, and in the writer's opinion experiments with imported wheat are to be deprecated not so much because, in the light of previous experience and from the nature of the case, they are likely to be failures as because they absorb time and attention that might be much more profitably bestowed in selecting

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and creating suitable varieties from native stocks. To introduce foreign wheats in order to attempt by intercrossing to impart to Indian wheats desirable qualities that these foreign wheats possess and that no Indian wheat exhibits is of course both logical and advisable; the introduction of foreign varieties, however desirable these may be in themselves, with a view to establishing them in India, is, so far as all the evidence available goes, a waste of endeavour. In any case, care must be taken to conduct all experimental cultures intelligently, whether the subject of the experiment be an Indian or an imported wheat. Merely to sow a series of samples for the sake of adding, at the end of the season, one more paper to a Government file in the shape of a record of the immunity from rust, or otherwise, of each, is to mistake the object of work of this kind and implies the loss of an opportunity.

The latest evidence from Europe (APPENDIX A) confirms the conclusion of Australian workers, that only by the *selection and creation* of new and rust-resisting varieties of wheat can loss from rust be hoped to be lessened. A perusal of Mr. Farrer's account of his methods (APPENDIX B) will show how much more is involved in the process of selecting and fixing types, than a mere record of the observations of a season and the preparation of a report at its close.

APPENDICES.

Appendix A.

THE PRESENT POSITION OF THE RUST-PROBLEM. [JAKOB ERIKSSON: DER HEUTIGE STAND DER GETREIDEROSTFRAGE.]

Translated from Bericht. der deutschen botanischen Gesellschaft. Jahrg. 1897. Bd. XV., Heft 3, s. 183—194.

For now more than six years a continued investigation of the rusts destructive to our cereal crops has been carried on at the experimental farm of the Royal Swedish Academy of Sciences. Results of this investigation have been published in various places;* but it is impossible to judge from these publications what the actual condition of the cereal-rust problem is, since there are some very important points, such as the spread of rust from one plant to another, and the effects of rust on the quality of seed, regarding which little or nothing has been said in the literature hitherto published. The continued and exhaustive examination of these two matters of detail is at length sufficiently advanced to permit of the publication of certain particulars.

In the pages that follow an attempt will be made, partly as supplementing already well-known results, partly too and indeed principally as the outcome of experience hitherto unpublished, to answer the practical question:—

> "Has the position of the cereal-rust problem been in any way altered as the result of the researches carried on so far, and if it has been altered, what has the change been?"

Among the more important results of this research the following may be first alluded to. It was formerly supposed that our four common cereals were affected by 3—4 species of rust-fungus. One of these species, *Puccinia graminis* Pers., was supposed to appear on all four cereals; another, *P. rubigo-vera* DC., was thought to be confined to rye and to wheat; a third, *P. coronata* Corda, was considered peculiar to oats; and a fourth, *P. simplex* Kcke (also known as *P. anomala* Rostr., and usually dealt with as a mere variety of *P. rubigo-vera*) was supposed to be similarly confined to barley. It was further imagined that all the cereals and grasses which bear one particular kind of rust are capable of infecting each other. This belief led naturally to the

* J. Eriksson und E. Henning; *Die Getreideroste, ihre Geschichte und Natur, sowei Massregeln gegen dieselben.* Stockholm 1896.—J. Eriksson; *Ueber die Specialisirung des Parasitismus bei den Getreiderostpilzen* (Ber. d. Deutsch. Bot. Ges. 1894, s. 292—331); *Ueber die Foerderung der Pilzsporenkeimung durch Kaelte* (Cent. Bl. für Bact. und Par-Kunde, Abt. 2, 1895, Bd. I. N, 15-16); *Ist die verschiedene Widerstandfaehigkeit der Weizensorten gegen Rost constant oder nicht?* (Zeitschr. für Pfl.-Krankh., 1895, s. 198—200); *Welche Grasarten koennen die Berberitze mit Rost anstecken?* (*Ibid.*, 1896, s. 193—197); *Neue Untersuchungen ueber die Specialisirung, Verbreitung und Herkunft des Schwarzrostes* (Puccinia graminis *Pers.*) (Jahrb. für wissensch. Bot., 1896, s. 499—524); *Welche Rostarten zerstoeren die australischen Weizenernten?* (Zeitschr. für Pfl-Krankheiten, 1896, s. 141—144); *Studien ueber den Hexenbesenrost der Berberitze* (Puccinia Arrhenateri *Kleb.*) (Cohn's Beitr. z. Biol. d. Pfl. Bd. 8., s. 1—16); *Vie tente et plasmatique de certaines Uredinées* (Compt. rend. 1897, 1er Mars.)

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conclusion that the origin of rust on cereal crops must be mainly attributed to its spread from adjacent rusted plants, particularly in the case of *P. graminis* which affects not only our four cereal crops but a whole host of ditch-, meadow- and forest-grasses in addition.

Our ideas regarding this subject must now be altered. It has been shown that, even if we deal only with our four cereal crops, we have to enumerate no fewer than ten sorts of rust, referable to five so-called "species." Thus—

of Black-rust (*Puccinia graminis*) we have—

(1) a form on rye and barley ;
(2) a form on oats, and
(3) a form on wheat :

of Brown-rust (*Puccinia dispersa*) we have—

(4) a form on rye, and
(5) a form on wheat :

of Yellow-rust (*Puccinia glumarum*) we have—

(6) a form on rye ;
(7) a form on wheat, and
(8) a form on barley :

of Pigmy-rust (*Puccinia simplex*) we have—

(9) a form on barley : lastly,

of Crown-rust (*Puccinia coronata*) we have—

(10) a form on oats.

Such of these ten forms as are attributed to one and the same species cannot be distinguished by structural or by metric characters ; yet one does not doubt that they differ essentially. The difference is displayed in the fact that each form is exclusively limited to some special cereal and is incapable of infecting any but this particular one. Oats infected with black-rust can only spread this black-rust on oats ; rye bearing brown-rust can only infect rye, and so on. The sole exceptions to this are rye and barley bearing black-rust, which are then mutually infective, and to a certain extent also wheat with black-rust which, in rare instances, is capable of imparting the disease to rye and barley.

Of the ten known forms of rust moreover there are but two—both of them referred to black-rust, *viz.*, *forma* "*secalis*," common to rye and barley and *forma* "*avenae*," peculiar to oats—that are capable of appearing on other grasses ; the former may affect *Triticum repens*, *T. caninum*, *Elymus arenarius*, *Bromus secalinus*, *Hordeum jubatum*, etc.; the latter may occur on *Dactylis glomerata*, *Alopecurus pratensis*, *Milium effusum*, *Avena elatior*, *A. sterilis*, etc. The remaining eight are absolutely exclusively limited to the special cereals that constitute their respective hosts.

As a result of this new experience we are still free to suppose, when endeavouring to trace the source of a cereal-rust, that rye or barley may have become diseased by mutual infection or by infection from neighbouring rusted couch-grass, and similarly that oats may have been infected by rusted plants of *Dactylis*, *Alopecurus*, etc. As regards the remaining eight forms of rust it is, however, useless to seek for their origin among the neighbouring grasses.

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There may be some who, knowing that rust on oats can appear in consequence of infection from specimens of such wide-spread grasses as *Dactylis*, *Alopecurus*, etc., when they happen to carry black-rust, will immediately conclude that this explains the great prevalence of black-rust on oats at the present time. Such a conclusion would, however, be rash.

Were neighbouring rusted-plants the chief source of the disease, then rye and barley should also be commonly affected by black-rust since both these cereals are capable of infection from couch-grass, which is an almost constant denizen of the edges of our fields and is of all wild-grasses the one most commonly affected by black-rust. Experience shows however that, on rye, black-rust is neither so common nor so destructive as it is on oats, and that on barley black-rust is quite rare.

Nor is this all. Only last year a number of observations were made which indicated that there may be but a trifling spread of the rust-pest even in cases where one would have expected its wide extension.

One such observation, relating to the spread of black-rust from couch-grass to barley, may be particularly mentioned. On an open path in the experimental farm running past the experimental plots, a few plants of couch-grass just beginning to shoot up at the commencement of June 1894, were permitted to remain untouched, in order to admit of observations being made on the onset and development of black-rust upon them. Alongside this path with couch-grass on it lay an experimental plot under barley. On 3rd July the first spots of black-rust showed themselves on the leaf-sheaths of a plant of couch-grass; by 13th July many uredo-pustules were present.

On both dates mentioned the barley-plot, which by the 13th July had come into ear, did not, in spite of the closest possible search being made, show a single spot of rust. Twenty days later even, on 2nd August, when the leaf-sheaths of the couch-grass were quite covered with rust-pustules, the barley-plot remained remarkably clean; there were but trifling traces of rust though it still retained plenty of green stems. It should be noted too that it rained every day from the 10th to the 13th July (measured rainfall, 20·4 mm.=·8 in.) and again every day from the 15th to the 22nd of the month (measured rainfall, 38·7 mm.= 1·6 in).

So slight a capacity for spreading cannot but be surprising when we think how readily the spores of black-rust germinate, and consider that the incubation-period, antecedent to the appearance of a new crop of pustules, amounts only to about ten days.

It is somewhat astonishing to find in connection with the spread of these rust-fungi from one plant to another that the uredospores though quite alive, should be distinguished by a special reluctance to germinate, yet such is undoubtedly the case. An instance of this is the yellow wheat-rust (*Puccinia glumarum* forma *Tritici*), the most destructive wheat-rust of Sweden and probably also of the other countries of Northern Europe. Here the power to spread shows itself to be exceedingly trifling even as between different sorts of the same cereal, indeed even between different strains of one sort. No one can have failed to notice, when walking about mid-summer through an experimental field in which different kinds of wheat are being grown, that this or that sort may have been so badly attacked by yellow-rust as to render one's clothes yellow so soon as one enters the wheat, while sorts growing hard by are practically free from rust.

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This fact was strikingly apparent in the experimental farm in 1894. In several parts of the trial-field different kinds of winter-wheat were intentionally arranged so that the most susceptible should be next the most resistant ones. In one particular spot there was a plot of the highly susceptible "Horsford's Pearl-wheat" surrounded in different directions by five slightly susceptible kinds, *viz.*, "Graf Walderdorff's Improved." "Squarehead," "Hungarian White," "Blé Pouard," "White Ribband" and "Paine's Defiance."

The results with these plots for the summer were as follows:—Pustules of yellow-rust were first observed on "Horsford's Pearl" on May 11th; on June 13th, or thirty-three days later, the degree of rustiness by the rust-scale was 2 (= sparingly rusted), whereas none of the other plots mentioned showed any rust. Ten days later, on 23rd June, the rust on "Horsford's Pearl" stood at 4, the highest figure on the rust-scale (= generally rusted), while two of the adjacent plots were quite clean and the other three showed only faint traces of rust.

What were the special reasons for the very trifling spread of rust in these cases? Several may be imagined; one cause may, perhaps, be the natural unwillingness of the spores to germinate, a second may have been unfavourable weather-conditions, a third may be some character of blade-structure in the five resistant kinds that prevents the rust-fungus from establishing itself.

In order to test the question, so far as the germinating power of the spores and the nature of the weather are concerned, the following experiment was made during the time of year when yellow-rust grows best and under weather-conditions that are deemed most suitable for its spread.

Early each morning for five days in succession (between 5 and 7 A.M. on June 8th, 9th, 10th, 11th and 12th) five very badly-rusted plants were selected from the plots of "Horsford's" wheat. The plants, all wet as they were, were carried carefully to the laboratory and the germinability of the spores on all the leaves carefully tested. The record of this research, the details of which cannot be set down here, enables us to see that notwithstanding daily rain (the total rainfall for the five days was 33 mm. = 1·2 in.) and continuous cloud the number of spores that germinated was very small; so insignificant that the germinability may in most cases be set down as = 0. From this we may conclude that the natural disinclination of the spores to germinate contributes essentially to the remarkably limited spread of this species of rust, and that this disinclination is not appreciably diminished even during several days of rain.

We have now to consider the third of the possibilities indicated above; that some kinds of wheat possess a special inherent power of resisting the fungus which may explain the limited spread, and that the source of this is to be looked for in some mechanical, chemical or other difference.

Some observations made in the summer of 1896 give a clear but at the same time unexpected answer to the question. These observations were made on plants of "Squarehead" and of "Horsford's" wheat grown in pots in two different series, one at the end of June, the other at the end of July. The spore-material was taken from the open field, the first time from "Horsford's," the second time from "Michigan Bronze" wheat; on both occasions a state of high germinability was induced by cooling the material with ice. The result was that in both series of

infections rust-pustules were produced on "Squarehead" wheat, which in the open was quite rust-free, just as plentifully as on "Horsford's" wheat which in the open showed itself the most rust-liable. We see from this that a capacity for resisting rust, such as has been postulated above, is not inherent in different kinds of wheat, and that it is not by this hypothesis that the variable rustiness of different sorts in the field is to be explained.

Similar observations of the remarkably slight capabality of spreading on the part now of one, now of another form of rust-fungus have already been made public,* and their number might be added to here. But for the present it may be enough to point out to the uninitiated that the part played by wind-carried spores in connection with the appearance and the intensity of rust-blight has hitherto been considerably overrated.

The statement of the thesis that eventual damage from rust does not, as a matter of primary importance, imply the constant importation of new disease-germs (spores) or the constant formation of new disease-centres, obviously alters very considerably the position of the whole cereal-rust question. One of the keystones on which the doctrine of the origin and the spread of cereal-rusts has hitherto depended, is thus, if not wholly removed, at least decidedly displaced. But if this be so, how are we to explain the fact, which still remains, that from an apparently insignificant beginning, cereal-rust is at times capable of attaining severe and destructive dimensions? We propose to examine whether already published researches cannot provide a new keystone to be inserted, if not in room of, at least alongside the displaced one.

Even in the earliest years of the investigation some observations were made that suggested the possibility of there being some other source of rust on cereals than the contagion of external origin assumed in the pathological handbooks. Thus autumn after autumn, 30 to 38 days after sowing, without any reference to whether adjacent plots had contained infective matter or not, yellow-rust regularly made its appearance on the most susceptible kinds of autumn-sown winter wheat, such as "Horsford's wheat," "Michigan wheat," etc.; similarly it appeared just as regularly, summer after summer, about a month after sowing, on those barleys of a like nature, such as "Skinless Barley" (*Hordeum vulgare* VAR. *cornutum*), sown at different times during the spring. Both the regularity and the length of the period accord badly with the theory of an external origin for the blight. From artificial infection it was found that the incubation-period is really only about 10 days, so that on the hypothesis that infection from outside may have preceded their appearance, one would have expected the rust-pustules to be earlier by 1—2 weeks according to the abundance of infective material in the neighbourhood and to the nature of the weather at the time.

Another striking observation, bearing on the nature and mode of appearance of this rust, was made during the autumn of 1892. In a long experimental plot extending in a south to north direction, sown with "Landreth's hard winter-wheat," a kind very susceptible to yellow-rust, the northmost and best lighted part of the plot became much affected by yellow-rust about six weeks after it had been sown, while the southern portion of the plot, extending to a wood by whose

* See particularly J. ERIKSSON, *Neue Untersuchungen* (Jahrb. für wissensch. Bot.: 1896, s. 511 folg.).

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trees it was partially shaded, was far less rusted; finally the end-furrows, which the sun barely reached at any period of the day, were almost altogether clean. A similar phenomenon was also observed during the same autumn in the experimental field in a small plot one corner of which was very much shaded by a tall ash. The more shaded the plots were, the less was the rustiness, though the time of sowing, treatment of the soil, etc., were the same. And along with diminished rustiness there was in both cases a taller and more slender habit of growth in the shaded than in the exposed plants. This observation is also wholly incompatible with the theory of external infection because under that hypothesis rust should have been worst in the shaded portion of the field owing to the moisture-conditions being there more decidedly favourable for the germination of the spores and the blade-structure more suitable for the penetration of their filaments. The observations, however, showed just the reverse.

It would be much too tedious to give a detailed account of the many experiments that have been made during the past five years and that bear on these two observations; regarding the definite relationship between the appearance of yellow-rust and time of sowing, and regarding the varying intensity of the rust according to the varying extent to which the portion of the field is exposed to light. The first observation afforded an opportunity of ascertaining—and experiments were devoted exclusively to this end—whether it may not at times, and possibly not so very rarely, happen that the source of the disease is present in the plant itself, perhaps in the seed-buds; and whether what really chiefly influences the intensity of the disease may not be the varying extent to which the existence of the fungus in the host-plant is favoured in different years by external circumstances. The details of these experiments will be given in a paper that is about to be published. In the meantime only the general course of the experiments will be indicated here by means of their actual results.

There seemed to be two ways in which the foregoing question might be decided. The one was that of experiment—to ascertain by conclusive trial whether rust is capable of appearing on such plants as are protected against any external infection throughout their growth; the other was that of anatomical investigation—to find whether any inherent disease-substance, if such a thing may be imagined, can be shown to exist.

These experiments were conducted according to two essentially different plans. The first method was as follows: At the commencement of spring, so soon as the snow had melted but before the faintest trace of yellow-rust could be detected, a number of outwardly perfectly normal young shoots were selected from a plot of wheat highly susceptible to yellow-rust. The young shoots were introduced into long spacious glass-tubes that were firmly fixed to stakes in the ground, and the shoots were allowed from that time onwards to grow inside the tubes. The tubes were stoppered with cotton-wool above and below to prevent access of spores from without, and in addition a small metal cap was adjusted above the upper end as a protection against rain. Experiments of this kind were conducted during 1893 and 1894. In the latter of these seasons, when the weather was more suitable for the development of yellow-rust and at the same time the arrangements for the experiment were more satisfactory, there came a time when rust, which appeared moreover on the plot also, was quite abundant on several of the selected stems.

From this it was clear that an outbreak of yellow-rust, at any rate on certain sorts of wheat, may be due to infective-material already present in the plant itself. But whence then is this infective-material derived? It is possible to suppose that it may have found its way into the tender sprout during the autumn preceding as the result of infection by germinating winter-spores that happened to be in the neighbourhood of the seed; it is, however, also conceivable that the seed had inherited the disease from the parent plant.

To decide this question a different experiment was devised. The plants during their growth were partly protected from infection from without, partly grown in soil from which all harmful infective-material had been removed by sterilizing. Experiments of this nature were commenced in the summer of 1892 and have since then been annually repeated in specially constructed culture-frames which may be spoken of as isolation-frames. The frames are from half to quite a man's height and have usually been quadrilateral. The glazed sides have been fixed in wooden corner-posts. The passages below for the entrance, and above, for the exit of air, have had a layer of cotton-wool inserted so as to keep out all infective-material and an iron roof has been fixed above the frame to keep off the rain. Under the frame has been placed an experimental tray filled with sterilized earth in which to grow the plants, the soil in the frame being watered with distilled water introduced through one of the corner-posts by means of a metal pipe. In the very first year of experiment (1892) it became clear that the solution of the foregoing question was to be by no means so easy as one might have anticipated. The abnormal conditions under which the trial-plants were developed in these culture-frames—abnormal in the first place because of the constant high temperature and again because of the diminished access of light, caused the plants to grow more or less unnaturally: they were taller, more slender and paler than those grown in the open. It has already been remarked that varying degrees of exposure to light in different parts of the field suffice to induce a difference in the growth of the plant and in the amount of rustiness; it has besides been always well known that the differences in the weather of one year as compared with another have been enough to make one year a rusty year and another the opposite. All the more then must the unnatural conditions that prevail within the culture-frames affect the issue of the struggle, which we have to suppose is always going on between the host-plant and its parasite! In the very first year the event proved that in this struggle victory lay with the host-plant; in absolute agreement with the condition of affairs in shaded cultivated-patches, not a trace of rust appeared within the frames.

In the years 1892 and 1893 an attempt was made, partly by shading, partly by vigorous ventilation, to induce a natural habit of growth in the plants under confinement. Neither method, however, appeared sufficient. The shading still further diminished the access of light and induced a more unnatural habit of growth than ever. Vigorous ventilation, which was tried in 1893 by means of a wind-vane driven by a steam-engine, on an experimental area that included 13 culture-frames, certainly lowered the temperature sufficiently so long as the sky was clouded; as soon, however, as the sun shone out the temperature in the frames rose 2°—3° above that of the air outside and remained higher even when the velocity of the wind-vane was increased. The plants still grew unnaturally and no rust appeared.

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In 1894 positive results were for the first time obtained in a trial-frame—a round glass-cylinder half a metre (about 20 in.) high. The plants experimented on were of the race of barley, highly susceptible to yellow-rust, known as "skinless." On the second blade of a plant, reckoned from below, yellow-rust pustules at once appeared in 4—5 parallel lines together 10 mm. long, and on the fourth blade of a second plant in 2—3 lines 30 mm. long, while finally black-rust pustules appeared on a third plant, on the sheath of the third blade at a height of 30·5 cm. (about a foot) above the base of the glass-cylinder.

In the summer of 1895 a new plan was adopted. In the quadrangular experiment-frames the three sides looking east, south and west, respectively, were made of double glass panes and during the day, as long as the experiments lasted, an unbroken stream of ice-cooled water was made to pass between these panes. It was found that by this means the temperature in the frames could be reduced at will to below that outside, even in bright sunshine. Unfortunately, however, this reduction of temperature was accompanied by greater diminution of light than in the case of frames with single sides, particularly as the frames were only half a man's height and the roof besides threw a shadow. In consequence of this deficiency of illumination the plants became slender and pale and yellow-rust appeared only in one of the frames. On one of five plants of "Skinless" barley grown in that frame yellow-rust pustules appeared about seven weeks after sowing, first on one blade, and a week later on two others, all three blades belonging to the same stem.

If, however, the results obtained hitherto during the search for evidence in support of the theory that disease-matter may be present in the grain itself, are neither so numerous nor so conclusive as could have been wished, yet they are, even in their present state, of such a nature that it is worth while to take account of the interesting and important conclusions to be derived from the investigations conducted so far.

The other method of ascertaining the existence of internal disease-material was that of microscopic examination. All endeavours to trace in this way any such internal disease-material were at first unsuccessful; this has been the experience of all who have hitherto sought for it. In the peripheral tissues of rust-shrivelled wheat-grains there occurred, it is true, as has been described elsewhere,* a copious fungus-mycelium and indeed at times a form of spore-case with germinating winter-spores. But all attempts to discover a mycelium in the embryo itself, whether latent in the grain, or passing from the grain into the embryo at the moment of sprouting, were wholly futile, and it was equally impossible afterwards to find any trace whatever of a fungus mycelium in the young plant during the first few weeks following the germination of the seed.

It is only at the time, 4—8 weeks after sowing, when rust-pustules first appear that such a mycelium can be found; even then it is only traceable in the immediate vicinity of the pustules.

* J. Eriksson and E. Henning, *Die Getreideroste, etc.*, s. 206, etc.

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How then is the origin of this mycelium to be explained when, during the period immediately preceding its appearance, no possible source of disease is to be found in the neighbourhood either in the shape of *Aecidium*, or of *Uredo*, or of *Puccinia?*

A key to the solution of this mysterious question was obtained in the summer of 1893. When a microscopic examination is made, under a high power, of very young yellow-rust pustules on wheat-leaves, it is found that in immediate continuation of the outmost sori of a row of pustules there occur, besides the usual cell-elements, a kind of peculiar, elongated, mostly faintly curved plasmatic corpuscles. These corpuscles may occur singly or several to each cell. Some seemed to swim about freely in the protoplasm, while others seemed to have bored through the cell-wall with one extremity or when branched with several extremities and so to have sent out inter-cellular mycelial threads. When the leaves were examined at greater distances from the outer sori of a row of pustules nothing noteworthy was found; close up to the edges of these sori the mycelial network was so copiously branched that no idea could be formed as to its origin.

The observation that has just been briefly detailed, gives, as I believe, a key to the solution of the riddle. These small plasm-corpuscles, at first swimming freely in the protoplasm, constitute a phase of the fungus, the primary phase, wherein the fungus by its independent appearance makes itself visible. The fungus has for weeks, months, possibly even years previously, led a latent existence in and alongside of the protoplasm of the host-plant. This latent existence may be termed the mycoplasm-phase of the fungus and thus a kind of symbiosis, mycoplasm-symbiosis, may be indicated,—a symbiosis that is probably more intimate than any hitherto known.*

At a particular stage of the development of the wheat-stem, always provided that the conditions as to light, warmth and moisture are such as meet the necessities of the case, a dissociation takes place in the joint-life of the two symbiotic partners. The way in which they part company is this :—the fungus becomes differentiated into an independent organism, to begin with in the form of one or more plasm-corpuscles in the protoplasm of the host-plant, and shortly thereafter as an inter-cellular mycelium derived from these corpuscles. The fungus thus, if only for a short time, the few weeks necessary for the formation of spores, takes up that position in the phase already familiar to us as the mycelial-phase. The portion of the plasm-corpuscle that passes out through the cell-wall forms the inter-cellular mycelium which presently gives rise to sori, that which remains within the chlorophyll-producing cells forms the organs that are familiar to us as the haustoria, which provide for the sustenance of the chlorophyll-destroying mycelium. If this differentiation of the symbiotic partners occurs, only a few days elapse before free rust-pustules appear.

The numerous experiments and observations on which the theory just expounded is based and only a few of which have been alluded to above, are about to be published in fuller detail; when this is done some account will be taken of the theoretical and practical bearing of the doctrine.

* Compare the parasitism of *Rozella* and of *Woroninia* in the cells of certain *Saprolegniaceae* according to M. Cornu (Ann. des. Sc. Nat. Bot. ser. V., Vol. XV, 1872) and to A. Fischer (Jahrb. für wiss. Bot., XIII, 1882); see also De Bary, *Vergleichende Morphologie und Biologie der Pilze* (Leipzig, 1884, s. 424).

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Appendix B.

I.—Mr. Farrer's Methods in Cross-breeding of Wheats.

(*Report of the Proceedings of the Fourth Conference, pages 14–17.*)

At the last Conference I had the privilege of indicating a line of action by means of which success in combating the rust pest can be secured—such a measure of success, at any rate, as is necessary to enable wheat-growing to become, as far as danger from rust is concerned, a fairly safe industry for farmers to take in hand in districts which are not too close to the coast. In order that this line of action might be entered upon, I offered to supply to such of the Governments of the different colonies as were in a position to take the matter in hand, seeds which had been produced by cross-bred wheats of the first generation from the cross, such cross-bred wheats having been made for the purpose of combining with ability to resist the rust pest suitability for our conditions and requirements. I pointed out that the diverse types which would be produced by such seeds would enable each colony to secure, by means of selection, individual plants that possess superior power of resisting rust, and fitness for its own climate and conditions, from which individual plants such varieties as we want could be made or fixed. From the, in most cases, rather meagre reports I have received in regard to the manner in which my cross-bred wheats have served the purpose for which they were distributed, I am led to think that I failed to point out sufficiently clearly what was to be expected from them, and in what manner they should be dealt with. It is my intention to endeavour to supply this omission in this paper, and to point out in detail the steps which ought to be taken for the purpose of getting such wheats as we want from my seeds. Before doing this I would wish it to be understood clearly that I myself went carefully through this work last summer, and that what I have to say has not merely been evolved from my own brain or imagination, but is the result of actual practical experience. The details I shall give, however, unfortunately do not represent the course I actually followed, but the routine I shall hope to go through next summer, when I shall endeavour to correct the mistakes and supply the omissions of last season.

Before I begin my description of the detail work of selecting the best plants for our purpose from the cross-breds, it will be well, I think, to dwell for a moment on the special difficulties that have to be overcome in making varieties which are both resistant of rust and suitable for our conditions and requirements. When, after some years of preliminary work, which I had been carrying on before these Conferences were instituted, I had become possessed of a number of varieties that were satisfactorily resistant of rust, I found they were all late sorts, and as our hot winds are apt to ripen late sorts prematurely, and before their grain has reached its full size and filled out, I saw that lateness of maturity was almost as serious a defect in a wheat for this country as its liability to rust. It became necessary, therefore, to make an attempt to combine earliness with the power of resisting rust. This, on the face of it, has

the appearance of being a task which could be easily accomplished by crossing rust-resistant and early varieties; but when it is considered that it may be that earliness and resistance to rust are incompatible qualities, that early and late wheats are in bloom at different times, that early rust-liable and late rust-resisting sorts belong to different types, and that crosses between varieties which differ widely are on that account difficult and tedious to fix and uncertain as to the character of the types they will produce when they are crossed, it will be seen that the task is not entirely an easy one. I have found, as a matter of fact, that in breaking this new ground I have had to work largely in the dark, and to spend much time in doing such preliminary work as ascertaining accurately the different qualities possessed by the varieties I proposed making use of as parents, and the degrees in which they were able to transmit their respective qualities to their progeny. This work has now been sufficiently done with a few varieties for me to be able to feel some degree of certainty in regard to the outcome of many of the crosses I am making, but very much still remains to be done. The work I have already done, however, makes me confident that my work in the future will be more effective than it has been in the past, and that with a smaller expenditure of labour and time; while all doubts have now been removed in regard to the success which is to reward our efforts; but I can see that the full measure of success, which is necessary to satisfy me, will not come so quickly as I had at first hoped. Resistant wheats can only be made early gradually—step by step.

In order to combine the qualities of earliness of maturity and resistance to rust in one variety by means of cross-breeding, late rust-resistant and early rust-liable sorts, as I have already pointed out, have to be mated. It will be well to pause for a moment, and consider what we ought to expect from the union of types which differ so widely in these two qualities, as well as in others, such as the relative hardness, size, character of the grain, etc. What we generally see in the analogous case of the Animal Kingdom, with which we are more familiar, when parents, that are not closely similar, are united is that, if the progeny be numerous, certain individuals inherit some of their characteristics almost entirely from one parent, combined with other characteristics which they have inherited almost entirely from the other parent; while as regards the majority of their characteristics they are intermediate in various degrees between both parents; and when this happens in different degrees and in a different manner with all the progeny, it will be seen how it comes that no two individuals of the same parentage are ever exactly alike, and that the greater the dissimilarity of the parents the greater will be the difference between the offspring of the same union. I will attempt to illustrate briefly what I mean; and for this purpose will make the case as simple as I can, and apply it to the subject we are actually dealing with.

Suppose I have mated a rust-resistant late with a rust-liable early variety of wheat. The greatest diversity of types will be shown by the offspring which grows from seed of the first generation from the cross—from such seed as I am distributing. Suppose we have 100 plants growing from such seeds, which are of the same parentage. Out of this number I would expect there might be one or two—say one—which has inherited in a very high degree, possibly even in as high a degree as the parents themselves possess them, the qualities we are seeking to secure from both parents. A few more—say five—I would expect to inherit

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high rust-resistant power from one parent, associated with moderate earliness from the other; and five more to inherit a high degree of earliness with fair rust-resisting power. The remaining eighty-nine I would expect to inherit these qualities in various degrees intermediate between the two parents; and something of this sort is what I actually find to occur in most cases. The work, then, of the person whose business it is to make use of these 100 plants is essentially the work of selecting as many of these eleven plants as promise to fill our requirements; and that work, as I have found out from actual experience, requires for its successful performance the closest attention, care, patience, thoroughness, and system. With regard to the first four of the these requirements I can, of course, give no help; I can only suggest that the work must be done in the field, and that it is impossible to do it anything like properly elsewhere. It is in connection with the last requirement that I hope to be able to give some help, and that I shall now endeavour to do.

As the principal quality we want to secure in the wheats we are aiming to get is that of offering resistance to rust, it is clearly important that we should seek to reject speedily and get rid of such plants as do not possess that quality; and as late planting is the means at our command by which rust-liability can be made to show itself with the greatest certainty, it is clearly advisable that we should plant our seed late. I do not think it advisable, however, to make this test an unnecessarily severe one, as it is not rust-liability under any conditions that we want to bring out, but rather to see what plants are rust-liable under the least favourable conditions to which they are likely to be exposed in ordinary farming. In recommending late planting, therefore, I do not think it ought to be made later than the middle of June; a most desirable time I would consider to be during the first half of June; and that the occurrence of rust will have been invited sufficiently for our purpose if the seeds are planted during that fortnight. As each plant has to be examined by itself for rust, closer planting in the rows than five inches from seed to seed will be found to be undesirable. A good distance between the drills is two links, or about sixteen inches. When they are that distance apart the work of examining the plants can be done with comfort.

After sowing, and until the plants begin to head, little work need be done beyond keeping down the weeds and occasionally breaking the surface of the ground with a Planet Junior or other hoe. A close study of the plants, however, during this period will often yield much that is of interest, and varieties can then often be separated by differences which cannot be seen at other times; but it is not until the plants begin to head that the work of selection begins.

The first thing to be noted in a drill of cross-breds is what plants are the first to come into ear. Such plants I am in the habit of marking with a black tie made from a strip of any cheap material that does not lose its colour from the weather and tears easily. The plants which show ears the first are not always the earliest to ripen or the most desirable; and in some cases in which the presence of a black tie shows that the time between heading and ripening has been long, the marked plant is rejected on that account. It would do at least equally well to mark the first plants that come into flower, instead of those that head the first; but in my own case it is more convenient to mark the latter. If any plant heads much earlier than any others in a drill, my custom is to mark it

with two ties, and the next early ones with one tie. I generally mark about six plants in a drill for earliness in heading.

The time rust begins to appear is generally a few days after the plant has gone out of bloom. It is early enough, however, to make the first examination for rust about a fortnight after that time. It is probable that, in the first examination, only the lowest leaves will be found to be affected. If most of the plants in a drill are found to have rust on them, then those that are clean should be marked by a tie of a distinct colour. If instead of a few plants being clean, few are found to be rusty, then the rusty plants should be pulled up, and got rid of at once, and none marked.

Ties of different colours should be used for marking in each examination of a drill; but the same colour should be used for the same examination in all the drills—that is to say, if pink be used for the first and chocolate for the second examination for rust in a drill, these colours should be respectively used for the first and second examinations for rust in all the drills. In every case the date of examination, the number of plants marked, and all particulars which may be wanted, such as the degree of freedom from rust each particular colour is a record of in each drill, should be entered in a field-book at the time of examination. After this, until the plants begin to ripen, examinations for rust should be made at intervals of about a week. These examinations will disclose the fact that in general the first parts of the plant to be attacked are the lowest leaves, next the middle leaves, after that the upper leaves, next the leaf-sheaths, and last of all the stalk or the part of the straw between the highest leaf and the ear. Very few plants, indeed, unless the season be one in which rust is remarkably scarce, escape having some rust on the lowest leaves ; in a few more the middle leaves remain clean, while the number in which the upper leaves remain unaffected is comparatively large. It is for this reason that, in passing plants for freedom from rust, I draw the line above the leaves, and consider all plants which, in a season when rust is ordinarily prevalent, have the straw (leaf-sheaths and stalks) entirely free from rust to be satisfactorily clean. In selecting, however, the most desirable plants from which to fix varieties, I should, of course, give a decided preference to those with ties on them showing that their leaves had remained rust-free, as well as to those which appeared to possess the most desirable qualities in other respects. Periodic and fairly frequent examinations for rust, and coloured ties to mark the results of such examinations, are quite necessary, because rust that is on a plant one day may have been washed off by rain on the next and because it is frequently impracticable, if not impossible, to tell with certainty after it is ripe whether a plant has been affected with rust or not.

The last examination for rust should be made when the earliest plants are beginning to show signs of ripening, or when the stock is beginning to change its colour. In this examination two ties should be used, one (dark-blue is the colour I use for this purpose) to mark those plants that have their straw entirely clean, and the other (red is my colour for this) to show those that are the first to ripen. If most of the plants in the drill have clean straw, I pull up the rusty plants, and enter in my field-book that all the plants left had their straw clean at this examination. If any of the plants are markedly earlier than all the other plants in the drill, I mark them by two red ties, and the next earliest ones by one. In all cases I mark about half a dozen of the earliest plants in a drill

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containing from eighty to 100. In selecting the earliest ripening plants, I mark those whose stalks change colour first. It is well, however, to be careful and to use discretion in this matter, as it frequently happens that plants ripen early because they are diseased. The appearance of the plant, and especially the manner in which the ears have filled, will show fairly well when this is the case. Plants that have ripened early because they are unhealthy should, of course, be rejected.

If the above system of marking has been carried out, the work of harvesting will be easy, and can be done quickly. One detail, however, which is essential, and should be continued in harvesting each generation until the variety is fixed, is that the plants be harvested separately, however much alike they may be outwardly, for I have frequently found that plants which are exactly alike, and had for that reason been placed in the same bundle, have differed widely in the character of their grain. It is easy to keep the plants separate by tying each into a bundle by itself. Care, however, must be taken to place the tie which goes round the bundle below the coloured marking-ties; and for this purpose the marking-ties should be slipped up the stalks to which they are attached before the ties are placed around the bundle. The several bundles from the same drill should be made into a single large bundle, and a label on which are recorded the parentage of the plants, the number of the drill from which they were taken, the character of the straw, etc., attached to it. If any plant that is harvested differs widely from the other plants which were taken from the same drill in the character of its straw or in its habit of growth, the fact should be recorded on a special label which should be attached to its own bundle. In practice, however, it is not very often that I have had occasion to do this. The large bundles should be provided with a loop by which they may be hung up.

In dealing with each drill only a few of the most desirable plants are, of course, harvested. Some of the plants, which the coloured ties on them show to be desirable as far as resistance to rust and earliness are concerned, have now to be rejected on account of other faults. It may be because they have poor or bearded heads, or because their chaff is too thin or too loosely attached to hold the grain, or because the straw is brittle or weak. It will be well, also, in harvesting to look out for plants that appear only to have escaped rust because, from being unhealthy, they have been too deficient in sap for the parasite to thrive on them. Such plants, which are by no means uncommon, are betrayed by their pinched ears. They should either be rejected, or, if harvested, should be regarded with suspicion and the fact noted on a label attached to them. In regard to the time of harvesting it will be better not to do it too soon after the plants are ripe. If they are left for a week or two exposed to the wind and weather, faults in their straw become more apparent, and a better opinion can be formed of their ability to hold their grain.

If the process I have attempted to describe has been systematically and thoroughly carried out, and if the bundles can be put away in a place where mice cannot get at them, the thrashing may be deferred until shortly before the seeds are wanted for planting; for it is better, I believe, to allow the grain to remain in the ear for some time than to thrash it out at once. The history of the different bundles has been secured; for it is recorded on them by the coloured ties and by the labels attached to the large bundles, and can be transferred to the envelopes in which the seed is placed when bundles are thrashed.

II.—Mr. Farrer's Suggestions as regards India.

(*From a letter addressed to the Secretary to the Government of India, Department of Revenue and Agriculture; August 1897.*)

I have much pleasure in forwarding to you . . . . . . a number of wheats which have been selected from my collection as being likely to prove suitable for the climate of India.

Most of the samples sent are of cross-breds made by myself, and many of them contain blood of Indian varieties—in some cases indeed the blood of Indian wheat predominates. Such crosses have generally been made with the object of securing the good qualities of the Indian varieties in combination with either (1) better straw, (2) superior rust-resistance, or (3) the quality of producing strong flour—that is to say, flour which will make a large quantity of bread. Some of the cross-breds sent contain nothing but the blood of weak-flour wheats such as are at present almost exclusively grown in Australia: wheats of that character are indicated on the packets containing them to be such; and although I would certainly not recommend them, on account of the inferior strength of their flour, as well as, in general, their liability to rust, I have thought it well to send samples of such wheats, if it only be for the purpose of furnishing contrasts which will make more prominent the good qualities of more desirable sorts. On each packet of wheat sent, I have in general written what I believe to be its milling quality *as regards the strength of the flour made from it.* Wheats which have a milling quality denoted by 1 are supposed to have, when they are grown here (New South Wales), a strength of 60 or above—that is to say, a sack of flour (200 lbs.) made from them will absorb 60 or more quarts of water in making dough fit for baking. In a similar manner a wheat of milling quality=2 is supposed to have a strength of between 55 and 60. The following table will give my scale shortly and clearly:—

A wheat of milling quality=1, gives flour of strength 60 or more.
" " " " =2, " " from 55 to 59 inclusive.
" " " " =3, " " " 50 to 54 "
" " " " =4, " " " 45 to 49 "

I do not think that any wheats of less strength than 48 have been sent: and when I tell you that 48½ is the average flour-strength of the wheats grown in Australia, you will see that the wheats sent are mostly much better than over average. In cases when a single (?) is attached to the flour strength given, it means that I have good data through its parents for the opinion I have given:, when two queries (??) are attached, my data are not so satisfactory. When I have written on a packet '1st generation,' the meaning is that the contained sample has been taken from plants grown from seeds which were made by artificial impregnation: in such cases nothing whatever has been done of selecting for the purpose of making varieties, and there will be the maximum amount of variation amongst the plants grown from such seeds.

In no case would I expect results worthy of attention to be secured the first year the seeds are planted. The work to be done the first year is to plant the seeds in drills (rows) about 16 or 18 inches apart and six

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inches or even more apart in the drills. At the first harvest those individual plants (3 or 4, or in exceptional cases fewer or more) from each drill which have shown excellence as regards freedom from disease (most especially), vigour of growth, habit, ability to resist — to produce good ears filled with plump grain in the face of heat and drought— productiveness, time of maturity—in fact as regards all such qualities as cause a wheat to be valuable for your (Indian) climate, should be carefully harvested by themselves. This can best be done by adopting a system of previously marking the plants while they are growing: and a good method of doing this marking is by tying to the plants strips of a light fabric (print, etc.) of different colours and patterns, always using the same colour or pattern to mark the same quality. These ties should remain attached to the plants until they are harvested and indeed until they are thrashed. They will then serve as records of the qualities which were shown by the plants during their growth and be useful in making final selection and in making notes on the packet in which the seeds are finally stored. Each selected plant ought to be harvested by itself, and the seed from it planted in a drill of its own. This rule ought never to be departed from even, and especially, in dealing with plants which are apparently exactly alike, until a fixed type has been secured. If the selections have been made carefully and judiciously, the second year will most likely show that one of the selected plants is better able to transmit its good qualities than the others. Attention should be specially paid to the progeny of this plant, and selections be made again of the best plants amongst them. By being careful to harvest selected plants singly right up to the time when a uniform type has been secured, I find that varieties can generally be obtained in three or four generations, and occasionally even in two. If the work of making varieties be done carefully and systematically, I have confidence in expressing an opinion that you will be able to make, from some of the cross-breds I am sending you, varieties which will be suitable for your climate, and more than that, which will possess sufficient power of resisting rust and the effects of dry weather and heat to be of value to you on that account. If instead of growing varieties of wheat which have originated no one knows how, and have originally commended themselves by the possession in a conspicuous degree of some one quality, either of productiveness or of beauty of grain, or of some other excellence, farmers had in the past been in the habit of cultivating varieties, which had been made systematically with the object of securing rust-resistance associated with the other qualities of a good wheat, I have no doubt (I say this cautiously and deliberately after having given close attention to the subject and experimented for 10 years) that the rust-pest would long ago have lost its terrors, and that they would be in a position to encounter the conditions of a rusty season without fear of an appreciable diminution of crop. . . . . The breeding, then, of rust-resisting varieties of wheat by mating varieties of good constitution but of unlike types, and in making varieties selecting *in the localities for which the varieties are wanted* from the varying progeny of such crosses, those plants which show themselves to be most highly rust-resistant, constitutes in my opinion a rational and efficient solution of the rust-problem, and probably the only practical solution.

* * * * * *

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Cross-breeding of Wheats. (*D. Prain.*

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I will bring before you yet another matter on account of its probable utility to you. For many years I have been in the habit of receiving wheats from foreign countries, and have noticed that if I plant the imported seed in a drill, while most of the plants will generally show conspicuous unfitness for our climate, I can generally nevertheless by careful examination find in a drill one or more plants which are free or relatively free from disease and have grown fairly well. By following the custom of planting the seeds from such plants only, I find I have almost invariably been able to secure quickly rust-resistant and acclimatised strains of many (probably of most that I have considered worthy of attention) of the varieties I have introduced. The principle appears to be indicated by this, that when a variety of a domesticated plant, which is reproduced by seed, is fixed in any locality or country, it is only fixed in regard to the conditions of that locality or country; and that removal to a fresh climate makes prominent differences between individuals which had before remained unseen. It is from this principle that I have formed an opinion that whenever seeds of a domesticated or even of a natural variety or species of plant are brought from a foreign country, they should in the first instance be planted in drills in such a manner that each plant can be examined, and that a process of fixing a variety afresh for its new home should be gone through. If this were done, I think the work of acclimatising plants would be made quicker and more successful. This principle I would apply to all plants propagated by seeds, and would even make use of it in transferring valuable wheats from one part of your country for trial in another.

Appendix C.

REPORTS IN COMMITTEE OF THE AUSTRALIAN INTER-COLONIAL WHEAT-RUST CONFERENCES.

I.—Report of Committee, First Conference.

The Committee appointed by the Conference to draw up a series of resolutions have considered it important in the first place that the magnitude of the damage occasioned by attacks of the rust fungus on wheat should be clearly and fully recognised. The loss can of course be estimated only approximately, but all the estimates indicate that it is a very serious one. During the last season, South Australia seems to have suffered most, estimates having been made in that colony showing a total loss in one season of about £1,500,000. In Victoria the estimates similarly indicate a loss of about £750,000. In New South Wales the loss has been estimated at £100,000, in Queensland at £20,000. For Tasmania no estimate is forthcoming, but the total loss suffered by the five colonies during the past season must have been not far short of £2,500,000 sterling.

For a proper understanding of how this loss arises, and for an intelligent application of preventive measures, it is necessary that the nature of rust and of the conditions favourable to its development should be generally known amongst wheat-growers. To this end a short description of the disease, illustrated by diagrams, is appended to this report.* From that description it will be gathered that the rust is a microscopic fungus, similar in its main characters to the ordinary green mould that grows in cheese and to the mildews which are commonly found in damp places on objects of every description. The rust fungus grows mainly in the tissues of the blade and the stem; it also attacks the ear, but does not, so far as at present known, directly attack the seed. By absorbing, however, the sap of the plant for its own use, it deprives the grain of its necessary nourishment, so that the seed matures in a pinched and shrivelled condition. It is stated by some authorities that when the parasite attacks the ear the wheat grain becomes more shrivelled than when only the stem and the leaves are attacked. Like all other fungi, wheat rust is propagated by spores or germs, which are produced in countless numbers, and some of which remain in the straw and the ear, some cling after threshing as dust to the seed; and some being carried about by the breeze, lodge in the soil or on other plants. There are two kinds of these spores, namely, the red ones which quickly germinate, and are the means through which the pest having once broken out is able to spread with its characteristic rapidity through an entire crop—and the black ones, known as resting-spores, which do not appear until about harvest time, and remain a whole season before they bud forth in new life; it is by means of these latter that the fungus under ordinary conditions is continued from season to

* As this subject is fully gone into in Chapter II of the *précis*, entitled "the Rust-problem," it is not necessary to reprint the description referred to.

season. The conditions favourable for the germination of these spores are the conditions favourable for the growth of almost all such fungus pests, namely, a warm, damp, still atmosphere. Any circumstances, such as an outbreak of warm weather immediately succeeding rain, such as damp ill-drained swampy ground, such as the shelter of thick hedges, and so on, which lead to the establishment of these conditions, are favourable to an outbreak of rust. The spores, as has been already observed, are carried about on the breeze, so that they become lodged on various plants. They do not, however, flourish on all plants; but on barley, oats, wild oats, canary grass, and many of the ordinary grasses they are known to thrive. Hence in devising preventive measures against rust, it is not sufficient to take into account only the circumstances which attend its attack on wheat. The fact that the circumstances leading up to an outbreak of rust are various, will explain many of the apparent discrepancies in the observations of practical wheat-growers, and will render easily explicable the conflicting evidence that is forthcoming. For it will be readily understood that in some cases weather conditions favourable to the rapid development of rust may not appear until late in the season, in which case early sown crops will, to a great extent, escape. This in most districts is the general experience. But, on the other hand, the favourable weather conditions may perchance fall very early in the season, and be succeeded by very unfavourable weather conditions; in such a case the early sown crops would suffer most. Or it may be that, in some seasons, while the conditions are favourable to the growth of rust, they are also favourable to the development of rust-resisting power in the wheat, or *vice versâ.* And also it will be understood that since the circumstances leading up to the conditions favouring the development of rust are various, so the measures taken to prevent an outbreak must be various. No one measure, no one specific, should be expected to be universally successful in its application. Past experience, however, has already brought to light and fully tested some important measures which may with advantage be immediately adopted. Experience has also shown the necessity of obtaining definite and reliable facts concerning the utility of various other measures, not yet fully tried, but which circumstances seem to indicate as being of a more or less promising character. It will also be apparent from the general tenour of the evidence that the devising and practical application of methods for coping with the rust pest will be a work of time and the result of continuous earnest effort. There will be no royal road to success; but, like all great improvements, it will be the outcome of gradual progress, and of the labours of many workers.

With these considerations before them, the Committee recommends the following as a report, which may be adopted by the Conference:—

This Conference, viewing with alarm the continued ravages of the rust pest in wheat, and believing it expedient that the various Australian Governments should use every legitimate means of assisting in the prevention of these ravages, submits the following resolutions:—

(1) In view of the very general experience that early sown wheat frequently escapes entirely free from rust at times when late sown crops are greatly damaged thereby, and that in almost all cases it is onsiderably less attacked than late sown wheat, this Conference recommends that early sowing be adopted in all cases where applicable. In making this recommendation, the Conference does not overlook the fact that in some years, owing to unseasonable weather, early sowing is impracticable,

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but at the same time recognises that it may be adopted in many cases where late sowing is now the practice.

(2) This Conference believes that cutting the wheat crop when the grain is in the dough stage is at all times desirable, but that in a rusted crop the practice, when applicable, is specially to be recommended as a means of securing a heavier yield and better sample.

(3) This Conference, fully believing that no such cereal as rust-proof wheat has yet been discovered, but that, as shown from experiments already carried out by importing different varieties from countries outside the Australian Colonies and by carefully selecting within the colonies, certain kinds have proved to be constitutionally able to resist to a considerable extent the ravages of this pest, recommends a continuance of this work of selection and importation, with a view to securing varieties most likely to prove remunerative to the wheat farmers of the various colonies.

And, it having been found, from evidence submitted to the Conference, that certain varieties of wheat believed to be rust-resisting when grown in one locality have succumbed to the pest when grown in another locality, this Conference considers that it would not be justified in specifying any particular varieties as possessing rust-resisting qualities under all conditions.

(4) Resolved that the advisability of growing wheat upon land previously fallowed, or in succession to crops of a different order, like maize, sorghum, clover, peas, lucerne, potatoes, etc., is earnestly recommended to our farmers, on the grounds that wheat thus grown has enjoyed a greater immunity from attacks of rust than when succeeding wheat, oats, and other like graminaceous plants, and upon broader grounds of sound practical farming. The general tenour of the many facts laid before the Conference is to the effect that better farming—the practice of rotation, fallowing, and the use of farm-yard manure indirectly, by applying it to the plants which precede wheat in the rotation—has resulted not only in better crops of wheat, but noticeably lessened damage from the rust scourge.

(5) This Conference, recognising that the locus of the resting-spores of the rust fungus is chiefly the straw of the infected crop, advises that, where practicable, all infected straw, tailings, or stubbles, and all grasses immediately adjoining thereto, be carefully burned; and that, where infected straw must necessarily be fed to stock or used for bedding, all the manure therefrom be well rotted, and applied to land about to carry a non-cereal crop.

(6) The Conference is of opinion that each of the Australian Governments should institute, as early as practicable, a series of experiments on as many of the following subjects as circumstances will allow, such experiments to be continued over a succession of years, and the results to be published periodically for free distribution among all concerned :—

(*a*) The effect, as regards rust, of manuring.

(*b*) The effect of applying lime, ferrous sulphate, and salt to the soil.

(*c*) Effect of applying to the rusted crops, by means of the Strawsonizer and otherwise, solutions of ferrous sulphate, salt, sulphate of copper, and other approved antiseptics.

(*d*) Effect of different methods of cultivation.

(*e*) Effect and economical application of drainage.

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(*f*) Expediency and best methods of using infected straw.
(*g*) Efficacy of burning all straw, weeds, and other plants in the infected field, and of using other disinfecting agencies with a view to destroying spores.
(*h*) Relative value of rust-shrivelled and healthy seed.
(*i*) Relative values of different varieties of wheat.
(*j*) Effect, as regards rust, of different times and modes of sowing.
(*k*) Effect of different times and modes of reaping.
(*l*) Investigations regarding plants that act as intermediary hosts, and regarding all plants that are affected by rust in the different colonies.
(*m*) Climatic conditions most favourable to development of rust.
(*n*) Value of any apparently suitable specific methods not mentioned in this list.

(7) The Conference affirms the value of publishing every autumn in each colony a map indicating the whole of the wheat-growing districts, illustrating the extent to which each has been affected by rust, and giving all data possible as to climatic and other conditions of past season.

(8) The Conference recommends the issuing of a series of questions to all farmers and others interested throughout the several colonies, with a view to eliciting as much individual experience as possible, and thence deducing some general laws for future guidance.

Melbourne, 11th March 1890.

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II.—Report of Committee, Second Conference.

The Committee of the second Conference of delegates of the Australian Colonies called together to consider the question of rust in wheat desire to record the fact that, since the last Conference, held in Melbourne in 1890, distinct advances have been made in our knowledge both of the life-history of the rust fungi occurring in Australia, and of possible methods of coping with the pest. On reference to the papers and records of experiences presented to the Conference, it will be seen that certain discoveries of an interesting nature have been made in regard to the predominance of the spring rust (*Puccinia rubigo-vera*) in the Colony of New South Wales during the past year, and a possible fourth stage of the autumn rust (*Puccinia graminis*), on a species of *Agropyrum*, the presence of germinating cells in the spermogonia of the same rust; and the grub or larvæ of a species of *Diplosis* which feeds on the rust, and may be instrumental in spreading the pest. Abundant evidence has been accumulated showing the existence in Australia of varieties of wheat which are constantly less liable to damage from rust than are other varieties. Evidence has been gathered by direct experiments, and by information received from farmers in response to questions issued to them, which confirms the soundness of the recommendations of last year's Conference in regard to early sowing, and the less liability to disease of crops grown in rotation; and it has also been shown that, as a rule, thinly-growing crops suffer less from rust in these colonies than do thickly-growing crops. In regard to curative measures—which as temporary and occasional expedients should not pass disregarded—the proper use of fungicides has been further indicated

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by last year's experiments. It has been found that a solution composed of one part of sulphate of copper and 400 parts of water destroyed the vitality of the rust spore, and that a solution of 1 oz. of sulphate of iron to the gallon of water when sprayed over a growing crop at a time when rust was about to break out prevented the appearance of rust until a fortnight or three weeks later; and even if applied when the rust had attacked the plant, destroyed all outward appearance of fungus, and prevented its reappearance until fourteen days afterwards. These, the Committee submit, are evidences of real progress in the important and difficult work with which the Conference has had to grapple.

After a survey of the facts in evidence, the Conference in Committee has drafted a series of resolutions, which are now submitted for formal sanction. These resolutions are the same as those of last year's Conference, together with certain modifications and additions suggested by the further evidence gained during the past twelve months.

The series is divisible into two classes, the first embracing measures which the Committee believes may with confidence be recommended for immediate adoption, with a view to lessening the chances of loss consequent on rust. These recommendations do not refer to the adoption of any specific remedies or preventives, but rather to the general improvement and modification of existing methods of wheat-growing, and the gradual introduction of better systems of farming. The facts accumulated in evidence, as well as the experience and knowledge of the individual members of the Committee—both of those members who are engaged in wheat-growing for the market, and of those who are engaged in scientific inquiry into the subject—unmistakeably indicate that the ravages of the rust pest would be materially decreased by intelligent perseverance in the direction of these general methods. The recommendations are not offered for indiscriminate adoption, but for selection or modification according to the results of local experience. The Committee believes that if all those interested in the advancement of agriculture would cordially unite in encouraging Australian farmers and wheat-growers to persevere in the direction of these recommendations, the result would be a most important diminution of the loss resulting from rust, and a steady increase in our output of wheat.

The second class of resolutions refers to methods and subjects of inquiry recommended for the coming season.

The resolutions are as follows:—

I.—Recommendations for the immediate attention of Farmers.

1. In view of the general experience that early-sown wheat frequently escapes free from rust at times when late-sown crops are greatly damaged thereby, and that in the great majority of cases it is attacked considerably less than late-sown wheat, this Conference recommends that early sowing be adopted whenever possible. In making this recommendation the Conference does not overlook the fact that sometimes, owing to unseasonable weather, early sowing is impracticable, but it also recognises that early sowing might readily be adopted in many cases where late sowing is now the practice.

2. This Conference believes that cutting the wheat-crop when the grain is in the dough stage is generally desirable as a means of securing a better sample of grain for milling purposes; and that in a rusted crop the practice is specially to be recommended to this end. This

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recommendation, however, does not refer to obtaining grain for seed, for which purpose the crop should not be cut until fairly ripe.

3. This Conference, believing that no such cereal as rust-proof wheat has yet been discovered, but that, as shown from experiments lately carried out by importing different varieties from countries outside the Australian Colonies, and by carefully selecting and hybridising them within the Colonies, certain kinds have been found to constantly escape to a considerable extent the ravages of this pest, recommends a continuance of this work of importation, selection and hybridisation, with a view to securing varieties most likely to escape rust and specially adapted to the different districts of our Colonies. And, it having been found from evidence submitted to this Conference, that certain varieties of wheat, believed to be rust-resisting, when grown in one locality, have succumbed to the pest when grown in another locality, this Conference considers that it would not be justified in specifying any particular varieties as possessing rust-resisting qualities under all conditions, but provisionally recommends the following as worthy of careful trial:—Ward's Prolific, Victorian Defiance, Queensland Defiance, Red Tuscan, Belatourka, Fill-bag, Du Toits, Rattling Tom, Blount's Lambrigg, and Leak's.

4. Inasmuch as rust-resisting wheats, when grown for a few seasons in rusty districts, are liable to lose their ability to avoid the attacks of the rust fungus, this Conference affirms the desirability of establishing at as early a date as possible in suitable districts of the different Colonies, seed depôts, or stations for the maintenance and improvement, by selection and hybridisation, of the rust-resisting and other desirable qualities of seed-wheats, and for the constant distribution of standard varieties throughout the Colonies.

5. This Conference desires to record its conviction that red wheats should be brought more generally into cultivation in these Colonies, for the reason that, while they are hard and well suitable for milling purposes with modern milling machinery, they are also less liable to the ravages of rust than are white wheats. It considers that the present prevailing demand on the part of grain merchants and millers for white wheats is not based on any sound principle, and it is prejudicial to the interest of wheat-growers and bread consumers.

6. The advisability of growing wheat on land previously fallowed, or in succession to crops of a different order, such as maize, sorghum, clover, peas, cow-peas, Indian grain, lucerne, and other Leguminosæ, potatoes, mangolds, and other root-crops, etc., is earnestly recommended to our farmers, on the grounds that wheat thus grown has enjoyed a greater immunity from attacks of rust than when succeeding wheat, oats, and other like graminaceous plants, and also upon broader grounds of sound practical farming. The general tenour of the many facts laid before the Conference is to the effect that better farming—the practice of rotation, fallowing, and the use of farm-yard manure indirectly, by applying it to plants which precede wheat in the rotation—has resulted, not only in better crops of wheat, but noticeably lessened damage from the rust scourge.

7. In view of the general evidence that in the Australian Colonies, thinly-sown crops are less attacked by rust than thickly-sown crops, the Conference recommends the more general adoption of the practice of thin sowing, due regard being given to the soil, the time of sowing, and the peculiarities of the local climate.

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8. This Conference, recognising that the locus of the resting-spores of the rust fungus is chiefly the straw of the infected crop, advises that, where practicable, all infected straw tailings or stubble and all grasses immediately adjoining thereto, be carefully burned; and that, where infected straw must necessarily be fed to stock, or used for bedding, all the manure therefrom be well rotted and applied to land about to carry a non-cereal crop.

II.—Recommendations for Enquiry and Investigation.

9. The Conference affirms the desirability of continuing experiments and inquiries in directions such as are indicated in the 6th Resolution of last year's Conference. The subjects for investigation fall under the following headings :—

(*a*) The effect, as regards rust, of manuring.

(*b*) The effect of applying lime, salt and sulphate of iron to the soil.

(*c*) The effect of applying to the rusted crops, by means of the Strawsonizer or otherwise, various fungicides in solution or in powder, such as sulphate of iron, salt, sulphate of copper, Bordeaux mixture, eau celeste, ammonic carbonate of copper, carbolic acid, and thymol.

(*d*) Effect of different modes of cultivation.

(*e*) Effect and economical application of drainage.

(*f*) Expediency and best methods of using infected straw.

(*g*) Efficacy of burning all straw, weeds, and other plants in the infected field, and of using other disinfecting agencies, with a view to destroying spores.

(*h*) Relative value of rust-shrivelled and plump seed.

(*i*) Relative value of different varieties of wheat.

(*j*) Effect, as regards rust, of different times and modes of sowing.

(*k*) Effect of different times and modes of reaping.

(*l*) Investigations regarding plants that act as intermediary hosts, and regarding all plants that are affected by rust in the different Colonies.

(*m*) Investigations as to the earliest stage of wheat in which the fungus may effect an entrance.

(*n*) Investigations regarding any insects, such as the recently discovered grubs of a *Diplosis*, which feed upon rust-spores and may be instrumental in spreading the pest.

(*o*) Investigations in regard to the influence on rust of interchange of seed between suitable localities.

(*p*) The influence which the growing of the seed in hot climates has on the early maturing of wheats.

(*q*) Investigations in regard to the effect of mixture of seed on the development of rust.

(*r*) Macroscopical, microscopical and chemical examination of varieties of wheat in order to discover the characteristics of rust-resisting wheats.

(*s*) Trials of various Leguminous plants from various parts of the world, suitable for introduction into rotations in the

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different districts of Australia, and especially into the wheat-growing districts of the dry interior.

(*t*) Investigations in regard to standard of rustiness and in regard to some more precise method of comparing the degree of rustiness than the use of vague expressions, such as "slightly rusty," "rusty," and "very rusty."

10. Resolved, that, for experimental purposes, an inter-colonial exchange of all varieties of wheat in the Colonies be effected in time for next season's sowing.

11. It is recommended that steps be taken by the various Governments to encourage the production or improvement of implements suitable for spraying wheat crops.

12. Resolved, that, as soon as possible, experiments on a sufficiently large scale be made in the various Colonies to demonstrate the most practical method of spraying crops with suitable fungicides.

13. The Conference affirms the value of publishing every autumn in each Colony a map indicating the whole of the wheat-growing districts, illustrating the extent to which each has been affected by rust, and giving all data possible as to climatic and other conditions of the past seasons.

14. It is recommended that the series of questions set forth in Appendix I* to this report, relating to the coming season's crop, be issued to the farmers in all the Colonies; and that together with these questions, an invitation be issued to the farmers to forward specimens of wheat and other plants upon which rust is found growing, instructions for gathering samples, as set forth in Appendix II,† being issued at the same time.

15. Resolved, that draft copies of all reports of investigation and experiments which are intended for presentation at the next year's Conference, be circulated amongst the various members at least a fortnight before session.

Sydney, 8th June 1891.

III.—Report of Committee, Third Conference.

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At the first of the present series of Conferences, which was held in Melbourne in 1890, to consider the question of rust in wheat, it was recognised that the annual loss in these Colonies caused by the ravages of the rust fungus were very serious indeed. It was estimated that in the season preceding that Conference, namely, the season of 1889-90, the total loss from this cause in the Australian Colonies could not have been less than £2,500,000. The constant presence of a pest which annually causes such serious losses required that determined and well-considered measures should be taken for the subjugation of the pest, and justified the incurrence of an adequate expenditure for the carrying out of investigations and experiments with a view to enlarging the common knowledge of the subject and of initiating measures for lessening the ravages of the pest. At that Conference a good deal of the already existing knowledge about this subject was focussed and carefully considered; but it was seen that this knowledge was in some directions of a

* Omitted. A series of 39 questions intended to bring out more clearly the facts regarding the points enumerated in paragraph 9 of this report.

† No Appendix II is given in the original.

vague and general character; moreover, much of the information tendered was very conflicting and not based upon precise and careful observation. Such information as was precise and well-established, was published in the report of that Conference and distributed amongst the farmers; but such information and opinions as were less certain were subjected the following season to the test of experiments conducted with as much exactness as was practicable. The influences upon the development of rust of various kinds of manuring, of treatment of the ground, treatment of the seed, different times of sowing, different times of reaping, of the variety of wheat grown, and so forth, were put to the test of experiments, which have now extended over two years. As a result of these experiments, it has been very clearly shown that, amongst those factors in the growth of wheat which are at present controllable by man, by far the most important factors relate to the times of sowing and the varieties of wheat grown. Manuring and treatment of the soil, methods of cultivation, times of reaping, etc., have an influence on the development of rust, but the influence is, generally speaking, trifling as compared with the influence of the variety of wheat grown and the time of sowing. It has been clearly shown that there are several varieties of wheat which, except under very unusual circumstances, are never seriously attacked by rust. And it has also been shown that in many districts early sown wheats of a rust-liable kind generally escape damage by rust when the same wheats sown late suffer seriously.

In view of these facts the Conference has now directed attention mainly to encouraging the growth of varieties less liable to be attacked by rust and also to early sowing. To this end it was found desirable to find out precisely what were the characteristics of those wheats which are less liable to be attacked by rust, and a step has been taken in this direction. In the first place, the following classes have been made in which to place the various wheats:—

First Class.—Rust-proof wheats, by which is meant wheats which will not permit the mycelium of rust to enter and feed on their tissues. Of such wheats there are no known examples.

Second Class.—Rust-resisting wheats, by which is meant wheats which in localities suited to their growth and under normal conditions resist at all seasons of the year either the entrance of the rust mycelium into their tissues, or its subsequent growth and outburst. Of this class many examples are known.

Third Class.—Rust-liable wheats, by which is meant wheats which under the usual conditions of growth offer no resistance to the rust. Australian wheats now mostly grown belong to this class.

Fourth Class.—Rust-escaping wheats, that is to say, wheats which, like the third class, are rust-liable, but which, if sown at the proper time, ripen so early as to be ready for harvest before the rust of an ordinary season can prevent a paying crop.

Of these two classes, the most important are the second and the fourth. The characteristics of the second class, namely, the rust-resistant wheats, have been found by thorough and close examination of twelve varieties to be as follows:—Firstly, the possession of a thick or tough skin, so tough that, although the rust mycelium may enter the plant by means of the open stomata, yet it cannot break through the skin in order to

mature and shed its spores, so that its further development is prevented; and, secondly, the presence of a waxy exudation on the surface of the plant similar to the bloom of fruit; this waxy covering when present about the mouths of the stomata prevents the rust mycelium from entering. Wheats possessing tough skins, and especially, if possessing the toughness of skin in conjunction with the waxy bloom, may be grown under all conditions suitable to their normal growth without suffering seriously from rust. On the other hand, the rust-liable wheats, which are characterised by the possession of a thin and tender skin and often by the absence of bloom, can be grown successfully during a rusty year only in one way, namely, by sowing at such time that the plant shall be for only a short period subject to the attacks of the rust fungus. As to the proper time of sowing such wheats, no universal rule can be given. Sometimes these wheats escape rust the most when sown early and sometimes when sown late; but in the great majority of cases which have been examined by the Conference early sowing has been very much the most successful. And when, in addition to early sowing, early maturing varieties are selected, the loss due to rust becomes, taking the average of experiences, comparatively trifling. With these facts now clearly and indubitably established, one may lay down a course of action which, if judiciously pursued, will certainly in great measure do away with the losses caused by rust. Thus there are many, perhaps the majority of wheat-growing districts where, if quick-maturing wheats be sown early, they, in nine cases out of ten, escape damage by rust. If then the farmers in these districts, when they have the opportunity of sowing early, should sow such varieties as Steinwedel and Australian Glory, which are quick-growing wheats, or even such prolific wheats as Fill Bag, Rattling Tom, and Farmer's Friend which, while not being specially quick-growing, are yet able to escape rust if sown early enough, they would run little risk of loss from rust. If, however, in such districts the farmer be prevented by late rains or other causes from early sowing, then he cannot sow this class of wheat without running serious risk. He should then on no account sow these wheats, but only those belonging to the class we have described as rust-resisting, a class which embraces such well-known wheats as Blount's Lambrigg (except for coast districts), Leak's Belatourka, Victorian and Queensland Defiance, Ward's Marshall's White, Smith's Nonpareil, Medeah, Talavera, Red Californian, Town and Country, and Mummy. In those districts where the crops, whether sown early or late, are equally liable to rust, then rust-resistant wheats alone should be sown at any time.

From the above it will be understood that the principal measure recommended by the Conference for dealing with the rust-pest is the growth of suitable varieties of wheat. But this is not the only measure that needs to be taken, for it has been clearly shown that the varieties of wheat, both the rust-resistant and the early maturing, are apt to lose their desirable qualities in the course of time, and, moreover, some of those varieties which are suitable in regard to their rust-resistance and early maturing are unsuitable for general purposes owing to the possession of other undesirable qualities, and hence it is necessary that a thoroughly efficient and organised system should be established for the maintenance or improvement of the qualities of suitable existing varieties, and for the production and distribution of new and improved varieties, and at the

present Conference, now held in Adelaide, a definite scheme of an intercolonial character has been proposed and discussed, and recommendations made for its immediate establishment. By means of this scheme the farmers will have distributed amongst them, time after time, as occasion may require, rust-resistant and rust-escaping wheats suited to their districts, the good qualities of which wheats will have been ascertained and proved by a stringent test before distribution.

The question of the marketableness of rust-resistant wheats has been considered by the Conference. It has been said that Australian millers will not buy them except at reduced prices. Supposing such were the case, the evil would not be so great as that of the rust-pest, for it is obvious that a crop of 14 bushels to the acre of a rust-resistant wheat sold at 3*s.* 9*d.* per bushel would be a very much better return than a crop of 5 bushels or 6 bushels to the acre of a rust-damaged crop sold at 4*s.* per bushel. But some of the highest quality wheats of the rust-resistant class have been submitted to the judgment of leading millers, who have pronounced them to be of a good milling character. Many of the resistant wheats produce grain containing a greater proportion of gluten than do the rust-liable wheats, which contain, on the other hand, a greater proportion of starch. But that these hard and highly glutinous wheats produce good and nourishing flour has been shown by the Conference. Bread of good quality has been made from this flour, and there seems little doubt that such bread is more nutritious than that made from starchy wheats. Probably the best bread can be made by mixing both classes of wheat, as is now done in England. When the value of these hard glutinous wheats becomes more widely known in these Colonies, there is no doubt that a greater demand for them will spring up. In the meantime, however, it should be pointed out that there is already a large and constant market for the class of hard wheats, namely, the export market, and the only condition necessary for the export of this class of wheats is that they should be grown in large quantities, that is to say, in shiploads.

In order to draw the attention of farmers to the rust-resistant wheats, the Committee has this year drawn up a resolution recommending that special exhibits of these wheats should be made at agricultural shows and prizes offered for them, and it is a significant fact, and one which shows how the work of the Conferences during the last two years has already borne fruit, that at the agricultural show now being held at Adelaide two very fine and complete collections of this class of wheats were exhibited, and prizes were awarded. This is probably the first exhibit of the kind in any of the Colonies.

In connection with the question of the market value of wheats, the Conference recommends that the agricultural department of each Colony should take steps to establish a system of testing wheats in the laboratory and reporting their value to the farmers. Small mills for the rapid testing of lb. samples have already been invented and brought into use.

In examining the varieties of wheat now grown in the Colonies, the conviction has forced itself upon the Conference that, while in one of the great staple industries of this country, namely, that of wool-growing, the breeds of sheep are distinctly named, pedigrees kept, and the rules of breeding well known; in the other great industry, namely, that of wheat growing, much confusion exists about varieties and their names, and

much remains to be learnt in regard to the rules which should be followed in producing and maintaining varieties. Steps have therefore been taken, in accordance with a resolution at the last Conference, for making a complete collection of all varieties now in the Colonies so as to compare them and decide upon a common system of names, and also experiments have been commenced for enlarging our knowledge concerning rules for improving the qualities of wheats and for producing new varieties.

While the Committee re-affirm their belief that the rust-pest will be subjugated mainly by action on the lines above indicated, yet they would encourage the continuance of experiments in other directions, and especially in the direction of spraying. The statements made at the Sydney Conference concerning the fatal effects of various fungicides on the germination of the rust-spores have been confirmed during the past season, but the difficulties attending the application of fungicides to wheat crops have not been wholly overcome, although progress has been made in this direction, and through the action of the Conference an important addition has been made to the machinery for applying sprays to crops cheaply and on an extensive scale.

The Committee consider it useful that questions similar to those issued last year, but shorter and fewer in number, should be re-issued to farmers during the coming season, and that returns should be called for by the statistical offices in each Colony showing the amount of loss suffered from the rust.

For the purpose of formally embodying the above policy, the Committee recommend that the following resolutions be adopted by the Conference :—

Recommendations for the immediate attention of Farmers.

1. In previous years this Conference has drawn attention under the head of "Recommendations for the immediate attention of Farmers" to certain practical rules of proved utility in checking the spread of rusts. These rules have come to the Conference as the personal experiences of individual members and through correspondence with the practical farmers and wheat-growers of every section of the Australian Colonies. Like all rules of agricultural practice, these recommendations are not to be taken as infallible ; nor are they offered as specifics for the disease which the Conference has been called to combat. They no more than represent certain well-marked and clearly-defined tendencies. But while it is true that the farmer whose practices conform to these recommendations may yet be a sufferer from the rust contagion ; it is absolutely certain that he will suffer in a much less degree than his neighbour who in practice ignores these dicta of the Conference. In this respect the experiences of the past season but add force to those of previous years. The Conference therefore desires, without going to the length of repeating the rules laid down in the reports of the Melbourne and Sydney meetings, to re-affirm with slight modifications the suggestions made in the reports of those meetings. Whatever other measures may be adopted by the farmers with the object of preventing the disease entirely or of arresting its further spread, the practices here suggested may not with safety be ignored. These recommendations, briefly stated, are as follows :—

I.—Early sowing and the cultivation of early ripening sorts.

II.—Harvesting rust-infected crops in the early or "dough" stage.

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III.—The growth of sorts which local experiences have shown to be rust-resisting or rust-escaping.

IV.—The growth of wheat after fallowing, or after crops of a different order, agreeable to the true principles of rotation.

V.—Thin seeding, with due regard to varieties and local conditions of soil and climate.

Prizes for Wheats at shows.

2. This Conference recognises the need of an awakened interest in the new facts bearing on rust-resistance, and believes that the agricultural shows may contribute largely to this object. We therefore urge upon local societies the importance of offering special prizes for collections of wheats of proved value as rust resisters. And it is further advised that these collections be kept separate from the general wheat exhibits, and that they be plainly labelled to the end that a wide publicity be given to the general subject, as well as to the characteristics of promising sorts.

Trial of Various Wheats.

3. This Conference believing that no such cereal as rust proof wheat has yet been discovered, but that, as shown from experiments lately carried out by importing different varieties from countries outside the Australian Colonies, and by careful selecting and crossing them within the Colonies, certain kinds have been found to constantly escape to a considerable extent the ravages of this pest, recommends a continuance of this work of importation, selection and crossing, with a view to securing varieties most likely to escape rust and specially adapted to the different districts of our Colonies. And it having been found from evidence submitted to this Conference that certain varieties of wheat, believed to be rust-resisting when grown in one locality, have succumbed to this pest when grown in another locality, this Conference considers that while it would not be justified in specifying any particular varieties as possessing rust-resistant qualities under all conditions, nevertheless particularly recommends the following, in the order given, as worthy of being grown on a large scale :—

A.—*Recommended for Growing on a Large Scale.*

I.—As rust-resistant—

(1) Blount's Lambrigg (not in coast districts), (2) Leak's, (3) Belatourka,* (4) Ward's Prolific, especially the strain known as Marshall's White, (5) Victorian Defiance, (6) Queensland Defiance, (7) Smith's Nonpareil, (8) Médéah,* (9) Talavera, (10) Red Californian, (11) Town and Country, (12) Mummy.

II.—As prolific and moderately resistant—

(1) Fill Bag, (2) Rattling Tom, (3) Farmer's Friend.

III.—As rust-escaping, if sown early—

(1) Steinwedel, (2) Australian Glory.

B.—*Recommended for further Trial on a Small Scale.*

I.—As rust-resistant—

(1) Fluorspar,† (2) Blount's Fife,† (3) Fultz,† (4) Tourmaline, (5) Niagara, (6) Improved Fife,† (7) Bega Wheat,

* Belatourka and Medéah are specially recommended for hot districts, either in the interior or on the coast.

† Of the above, Fluorspar, Blount's Fife, Fultz, Improved Fife, and Hornblende are not recommended for coast districts.

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(8) Anglo-Australian* or Anglo-Canadian, (9) Manitoba, (10) Square-headed Sicilian, (11) Sicilian Baart,* (12) Clarke's Rust-proof, (13) Hornblende,† (14) Pugh's Rust-proof, (15) Summer Club.

II.—As rust-escaping—

(1) Jacinth, (2) Quartz, (3) King's Jubilee, (4) Square-headed Sicilian, (5) Early Para, (6) Australian Wonder.

Recommendations for Government Action.

4. Resolved.—That it is desirable that a practical system for the production and distribution of rust-resisting wheats suitable to different districts should be immediately established, and this system should, subject to modifications needed by each Colony, be conducted on the following lines :—A central station for each Colony for the preliminary testing of new wheats introduced into the Colony, for the production of new varieties by cross-fertilisation and by selection, and for the distribution of suitable wheats thus obtained to representative districts of the Colony ; to be there subjected to a sufficient test and, if necessary, fixed in their characters by farmers and others competent for the work, and that such wheats as pass satisfactorily this test should then be distributed to the farmers around in such a manner and by such agency as would be most suitable to the conditions of each Colony.

Nomenclature.

5. Resolved.—That in connection with the inter-colonial exchange of seed now being carried out steps be taken for the proper naming of the different varieties of wheat, and that Dr. Cobb, Mr. Farrer, Professor Lowrie, Professor Shelton, Rev. H. E. Thompson, and Mr. Pearson be appointed a committee for the purpose.

Experiments.

6. The Conference re-affirms the desirability of continuing experiments and inquiries in directions such as were indicated in the sixth resolution of last year's Conference. The subjects for investigation fall under the following headings :—

(*a*) The effect, as regards rust, of manuring.
(*b*) The effect of applying lime, salt, and sulphate of iron to the soil.
(*c*) The effect of spraying.
(*d*) Effect of different modes of cultivation.
(*e*) Effect and economical application of drainage.
(*f*) Expediency and best methods of using infected straw.
(*g*) Efficacy of burning all straw, weeds, and other plants in the infected field, and of using other disinfecting agencies with a view to destroying spores.
(*h*) Relative value of rust-shrivelled and plump seed.
(*i*) Relative value of different varieties of wheat.
(*j*) Effects, as regards rust, of different times and modes of sowing.
(*k*) Effect of different times and modes of reaping.

*Anglo-Australian and Sicilian Baart are recommended for coast as well as for interior districts.

† Of the above, Fluorspar, Blount's Fife, Fultz, Improved Fife, and Hornblende are not recommended for coast districts.

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(*l*) Investigations regarding plants that act as intermediary hosts and regarding all plants that are affected by rust in the different Colonies.

(*m*) Investigations as to the earliest stage of wheat in which the fungus may effect an entrance.

(*n*) Investigations regarding any insects, such as the recently discovered grubs of a *Diplosis*, which feed upon rust spores and may be instrumental in spreading the pest.

(*o*) Investigations in regard to the influence on rust of interchange of seed between suitable localities.

(*p*) The influence which the growing of seed in hot climates has on the early maturing of wheats.

(*q*) Investigations in regard to the effect of mixture of seed in the development of rust.

(*r*) Macroscopical, microscopical, and chemical examination of varieties of wheat in order to discover the characteristics of rust-resisting wheats.

(*s*) Trials of various Leguminous plants from various parts of the world, suitable for introduction into rotations in the different districts of Australia, and especially into the wheat-growing districts of the dry interior.

(*t*) Investigations in regard to a standard of rustiness and in regard to some more precise method of comparing the degrees of rustiness than the use of vague expressions such as "slightly rusty," "rusty," and "very rusty."

(*u*) Determination of the particular kind of *Puccinia* affecting the crops in different districts and the damage done by each.

(*v*) Investigations to determine the presence or absence of the rust fungus in the seed.

(*w*) The effect, as regards rust, of the treatment of the seed before sowing.

Questions to Farmers.

7. Resolved.—That the following series of questions on rust in wheat, relating to the coming season's crop, be issued to the farmers in all the Colonies :—

At the Inter-Colonial Conference on Rust in Wheat, held in Adelaide in March 1892, it was recommended that the following questions be submitted to the wheat-growers of Australia. Special attention is called to the fact that the questions cover in part the same ground as those issued last year. It is hoped that the experiments and discussions resulting from the questions of last season have given rise to more valuable opinions among wheat-growers, and that therefore all growers who undertake to answer the questions here submitted will be even more particular than formerly to give as complete and exact information as possible, even though information of a similar kind was forwarded last year. It is requested that the answers to these questions be sent in not later than the 21st January, 1893 :—

Name ____________________

Address of farm ____________________

Parish ____________________

County or Division ____________________

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(1) How many acres of your land were under wheat this season?
(2) What portion of this was damaged by rust, and what was the loss per acre on that portion?
(3) What kind of season have you had this year?
(4) Give the date when the first speck of rust was observed in your crop.
(5) Give the date when the rust spread throughout your crop so as to do damage.
(6) State the kind of weather at this time.
(7) What was the time of sowing the seed? Was this early or late for the district?
(8) What kinds of wheat did you grow this year?
(9) What varieties have you found this year most affected and least affected by rust?
(10) Did the rusty crop start thinly or thickly on the ground?
(11) What has been your experience this season with shrivelled seed as compared with plump seed?
(12) Did you cut any of your rusted crop in the dough stage? If so, what were the results as to yield?
(13) Does wheat from colder or warmer, wetter or drier districts, suffer most from rust with you?
(14) Name any other plants, and especially grasses, upon which you have observed rust. If possible, send samples of such plants.
(15) What results have you obtained from any measures of prevention you may have tried?
(16) What kind of soil and sub-soil have you?
(17) Is there any other information you would like to give?

Publication of Reports on Experiments.

8. Resolved.—That it is desirable that reports of the coming season's inquiries and experiments in each Colony be published by the respective Governments in the ordinary departmental publications, and that an inter-colonial exchange of these reports be effected in the usual way.

Adelaide; March 12th, 1892.

IV.—Report of Committee, Fourth Conference.

Preamble.

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It seems proper that this Conference should give to the public certain facts regarding the evolution of the work it now has in hand. It will be remembered that the series of Australian Conferences on Rust in Wheat, of which the present is the fourth, is the first of the kind ever held. Precedents that might serve as guides in the work that was expected of them were, of course, entirely wanting. It has been necessary, therefore, not merely to devise methods of work, but the means by which plans were given effect to had, in many cases, to be created. The Conference had no inherent powers by which it could create new facts. Until quite recently it has had to rely for its facts concerning the more practical bearings of the problem it has had to deal with upon answers to questions put forth by the Departments of Agriculture of the several Colonies. These replies were often very useful, but often they were conflicting and irrelevant. It was felt, almost from the first, that the

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Conference must take steps to create a mass of experimental facts that would have an undoubted bearing upon the work in hand. To this end its members have carried out a vast and most comprehensive scheme of experiments, scientific and practical, the details of which occupy much of the volume of reports that have been given to the public. This experimental work has covered subjects of which the following are a part only :—

(1) The relation of applied manures to the spread of the rust contagion.
(2) Effect of fungicides applied in spraying.
(3) Effect of cultivation.
(4) The character of flag and straw of wheats as influencing the spread of the disease.
(5) The extent to which the rust spores adhere to seed wheat.
(6) Microscopical, chemical, milling and baking tests of wheats, made with the purpose of determining the relation of rust-resistance to known qualities.
(7) Influence of insects as carriers of rust spores.
(8) Determination of the particular kind of *Puccinia* affecting crops in different districts.
(9) Effect (upon rust) of different times and modes of sowing wheat.
(10) The creation of rust-resistant sorts by cross-fertilisation and selection.
(11) The relative value of different varieties of wheat.

In carrying out the experiments of which the above is an outline, members of the Conference have unanimously been led to the conclusion that efforts in this direction may most hopefully be turned towards the study of the wheat plant itself. We recognise that the wheat plant is naturally endowed with certain qualities, active or latent, which are susceptible of development to such a degree as to make it, to a very great extent, proof against the attacks of rust. Evidence has been presented to this Conference that, as far back as 1867, the rust-resistant powers of certain varieties have been recognised by practical farmers of the older wheat-growing Colonies. Acting upon their own success and failures, and the available facts of practical life, the members of the Conference have been led step by step, as by a common impulse, to direct their efforts, almost exclusively, to the work of bringing to light those sorts which possess in the highest degree rust-resistant power. In this way, the reports of the Conference have come to be, almost exclusively, a record of the work of its members, and latterly of efforts put forth to develop or discern this quality of rust-resistance.

The proportions this new work has assumed under the hands of the representatives of the several Colonies may be gathered from a few brief statements of facts :—The representatives of New South Wales have an experimental list of something over 500 varieties ; Victoria, 315 ; South Australia, 340 ; Tasmania, 150 ; and Queensland, 250 different sorts. All told, the growth and behaviour of no fewer than 500 different sorts of wheat have been under examination by the different members of the Conference during the year last past. That the labours involved in these experimental undertakings are fruitful, and for the present full of promise of larger things in the near future, is shown by the facts given below respecting old-established and comparatively well-known varieties.

By the use of new and unfamiliar sorts the list given might be greatly lengthened.

In all the five Colonies that have been represented at these Conferences the following varieties have enjoyed more or less immunity from rust attacks :—Improved Fife, Blount's Fife, White Fife, Blount's Lambrigg, Marshall's No. 3, Tourmaline, Pringle's Defiance, Fluorspar, Allora Spring, Hornblende, Sicilian Baart, and the various Durums.

A like unanimity is shown in respect to the sorts which have most readily succumbed to the disease. This list, of course, is too long for reproduction here. It is sufficient to say that the most pronounced of these are the numerous prolific members of the Purple Straw family with, among others, the Golden Drop, Tuscan, and Velvet Chaff varieties, all connected by certain affinities, the most pronounced of which are a large cropping capacity under favourable conditions, extreme whiteness and plumpness, with a corresponding granular structure of grain indicating the presence of much starch.

One of the noticeable results of the labours of the Conference is seen in the present hopeful view of the situation—as to rust contagion—now taken by practical men. The number of persons who believe that complete immunity from rust in the wheat crop will be secured is, perhaps, as few as ever, but the existence of the feeling that the disease may be minimised or so completely held in check that the loss from it will be small, is now all but universal.

The obstacles to the final success of the work of the Conference and the nature of the obstacles likely to be encountered in the future are suggested by the following facts :—

(1) The varieties which suffer most from rust, among which the disease is most easily communicable, are the white, highly starchy, and often prolific sorts made familiar in the practices of Australian farmers.

(2) The sorts least susceptible to the rust disease, that are most strongly resistant thereto, are generally hard or horny in texture, and often, though not always, dark in colour.

(3) These really rich wheats are constantly discriminated against by Australian millers, whose machinery, it would appear, is inadequate to the work of successfully manipulating them, and who, to a certain extent, set the fashion in flours.

It has been brought to the attention of this Conference that varieties of wheat, which in America and Europe are accounted of first value, from which indeed a large part of the flour of commerce is made, and which in Australia have shown themselves possessed of great rust-resistant power, are here, by millers, placed so low in price that their cultivation is rendered unprofitable. It is incredible that these hardy, high-quality, red and amber wheats shall be forever excluded from Australian agriculture, that Australian farmers are doomed, as it were, to cultivate only those varieties which are whitest—*i.e.*, richest in starch—least nutritious, and which easiest fall prey to the rust disease. Surely it is only reasonable to expect, in view of the vast interests involved, that the efforts of this Conference, looking to a common understanding among farmers, millers, and the scientific men who have given direction to much of these experimental efforts, should be heartily seconded by all interested. We therefore, in this special manner, direct attention to the resolution given further on, which suggests an Inter-Colonial Conference

App. C. iv. of millers, producers, and scientific men for the consideration of the question of the milling qualities of rust-resistant wheats.

This Conference desires to emphasise the recommendations of previous Conferences of this series. The effect upon the development of rust of manuring, of treatment of seed, times of sowing and reaping, are doubtless, under certain circumstances, often considerable; but taking things by and large, they must be reckoned as trifling, compared with the influences of variety and time of sowing. We have shown conclusively, in the experiments of a series of years, that certain varieties of wheat are rarely, if ever, seriously affected by rust. Many other sorts, again, of a rust-liable kind, generally escape the rust when sown early, but suffer seriously when late seeding is practised.

The importance of distinguishing clearly varieties likely to suffer or escape the effects of rust contagion is recognised by the Conference in the appointment of a Nomenclature Committee, whose work in this connection is shown in their report herewith. Preliminary to the work of this Committee, the following classes have been made, in which to place the various wheats :—

First Class.—Rust-proof wheats, by which is meant wheats which will not permit the mycelium of rust to enter and feed on their tissues. Of such wheats there are no known examples.

Second Class.—Rust-resisting wheats, by which is meant wheats which in localities suited to their growth and under normal conditions resist either the entrance of the rust-mycelium into their tissues, or its subsequent growth and outburst. Of this class many examples are known.

Third Class.—Rust-liable wheats, by which is meant wheats which, under the usual conditions of growth, offer no resistance to the rust. Australian wheats now mostly grown belong to this class.

Fourth Class.—Rust-escaping wheats, that is to say, wheats which, like the third class, are rust-liable, but which, if sown at the proper time, ripen so early as to be ready for harvest before the rust of an ordinary season can prevent a paying crop.*

Of these four classes the most important are the second and the fourth. The characteristics of the second class—namely, the rust-resistant wheats, have been found by a thorough and close examination of many varieties to be as follows :—*First*, the possession of a thick or tough skin, so tough that, although the rust mycelium may enter the plant by means of the open stomata, yet it cannot break through the skin in order to mature and shed its spores, so that its further development is prevented; and, *second*, the presence of a waxy exudation on the surface of the plant similar to the bloom of fruit; this waxy covering when present about the mouths of the stomata prevents the rust mycelium from entering. Wheats possessing tough skins, and especially if possessing the toughness of skin in conjunction with the waxy bloom, may be grown under all conditions suitable to their normal growth without suffering seriously from rust. On the other hand, the rust-liable wheats which are characterised by the possession of a thin and tender skin, and often by the absence of bloom, can be grown successfully during

* Most likely a fifth class—namely, rust-enduring wheats—might properly be added.

a rusty year only in one way, namely, by sowing at such time that the plant shall be for only a short period subject to the attacks of the rust fungus. As to the proper time of sowing such wheats no universal rule can be given. Sometimes these wheats escape rust the most when sown early and sometimes when sown late; but in the great majority of cases which have been examined by the Conference, early sowing has been very much the more successful. And when, in addition to early sowing, early-maturing varieties are selected, the loss due to rust becomes, taking the average of experiences, comparatively trifling. With these facts now clearly and indubitably established one may lay down a course of action which, if judiciously pursued, will certainly in great measure do away with the losses caused by rust. Thus there are many, perhaps the majority, of wheat-growing districts where, if quick-maturing wheats be sown early, they in nine cases out of ten escape damage by rust. If, then, the farmers in these districts, when they have the opportunity of sowing early, should sow such varieties as Steinwedel and Early Para, which are quick-growing wheats, or even such prolific wheats as Hudson's Early, Purple Straw, Talavera, or White Lammas, which, while not being specially quick-growing, are yet able to escape rust if sown early enough, they would run little risk of loss from rust. If, however, in such districts the farmer be prevented by late rains or other causes from early sowing, then he cannot sow this class of wheat without running serious risk. He should then on no account sow these wheats, but only those belonging to the class described further on as rust-resistant.

From the above it will be understood that the principal measure recommended by the Conference for dealing with the rust-pest is the growth of suitable varieties of wheat. But this is not the only measure that needs to be taken, for it has been clearly shown that varieties of wheat, both the rust-resistant and the early-maturing, are apt to change their character in the course of time, and, moreover, some of those varieties which are suitable in regard to their rust-resistance and early-maturing are unsuitable for general purposes owing to the possession of other undesirable qualities, and hence it is necessary that a thoroughly efficient and organised system should be established for the maintenance or improvement of the qualities of suitable existing varieties, and for the production and distribution of new and improved varieties, and at the present Conference a definite scheme of an inter-colonial character has been proposed and discussed and recommendations made for its immediate establishment. By means of this scheme the farmers will have distributed amongst them, time after time, as occasion may require, rust-resistant and rust-escaping wheats suited to their districts, the good qualities of which will have been ascertained and proved by a stringent test before distribution.

The question of the marketableness of certain rust-resistant wheat has been considered by the Conference. It has already been stated that Australian millers will not buy them except at reduced prices. Supposing such were the case, the evil would not be so great as that of the rust-pest, for it is obvious that a crop of 14 bushels to the acre of a rust-resistant wheat sold at 3*s.* 9*d.* per bushel would be a very much better return than a crop of 5 bushels or 6 bushels to the acre of a rust-damaged crop sold at 4*s.* per bushel. But some of the highest quality wheats of the rust-resistant class have been submitted to the judgment of leading millers, who have pronounced them to be of a good milling

App. C. iv. character. Many of the resistant wheats produce grain containing a greater proportion of gluten than do the rust-liable wheats, which contain, on the other hand, a greater proportion of starch. But that these hard and highly glutinous wheats produce good and nourishing flour has been shown by the Conference. Bread of good quality has been made from this flour, and there seems little doubt that such bread is more nutritious than that made from starchy wheats. Probably the best bread can be made by mixing both classes of wheat, as is now done in England. When the value of these hard glutinous wheats becomes more widely known in these Colonies, there is no doubt that a greater demand for them will spring up. In the meantime, however, it should be pointed out that there is already a large and constant market for the class of hard wheats—namely, the export market—and the principal condition necessary for the export of this class of wheats is that they should be grown in large quantities, that is to say, in shiploads.

In connection with the question of the market value of wheats, the Conference recommends that the Agricultural Department of each Colony should take steps to establish a system of testing wheats in the laboratory and reporting their value to the farmers.

In examining the varieties of wheat now grown in the Colonies the conviction has forced itself upon the Conference that, while in one of the great staple industries of this country—namely, that of wool-growing—the breeds of sheep are distinctly named, pedigrees kept, and the rules of breeding well known; in the other great industry—namely, that of wheat-growing—much confusion exists about varieties and their names, and much remains to be learnt in regard to the rules which should be followed in producing and maintaining varieties. Steps have, therefore, been taken in accordance with a resolution of previous Conferences for making a complete collection of all varieties now in the Colonies so as to compare them and decide upon a common system of names, and also experiments have been commenced for enlarging our knowledge concerning rules for improving the qualities of wheats and for producing new varieties.

For the purpose of formally embodying the above policy the Committee recommends that the following resolutions be adopted by the Conference :—

Recommendations for the Immediate Attention of Farmers.

1. In previous years this Conference has drawn attention under the head of "Recommendations for the Immediate Attention of Farmers" to certain practical rules of proved utility in checking the spread of rusts. These rules have come to the Conference as the personal experiences of individual members, and through correspondence with the practical farmers and wheat-growers of every section of the Australian Colonies. Like all rules of agricultural practice, these recommendations are not to be taken as infallible, nor are they offered as specifics for the disease which the Conference has been called to combat. They no more than represent certain well-marked and clearly defined tendencies. But, while it is true that the farmer whose practices conform to these recommendations may yet be a sufferer from the rust contagion, it is absolutely certain that he will suffer in a much less degree than his neighbour who in practice ignores these dicta of the Conference. In this respect the experiences of the past season but add force to those of previous years. The Conference,

therefore, desires, without going to the length of repeating the rules laid down in the reports of the Melbourne, Sydney and Adelaide meetings, to re-affirm with slight modification the suggestions made in the reports of those meetings. Whatever other measures may be adopted by the farmers with the object of preventing the disease entirely or of arresting its further spread, the practices here suggested may not with safety be ignored. These recommendations, briefly stated, are as follows :—

I.—Early sowing and the cultivation of early-ripening sorts.
II.—Harvesting rust-infected crops in the early or "dough" stage.
III.—The growth of sorts which local experiences have shown to be rust-resisting or rust-escaping.
IV.—The growth of wheat after fallowing, or after crops of a different order, agreeable to the true principles of rotation.
V.—Thin seeding, with due regard to varieties and local conditions of soil and climate.

Prizes for Wheats at Shows.

2. This Conference recognises the need of an awakened interest in the new facts bearing on rust resistance, and believes that the agricultural shows may contribute largely to this object. We, therefore, urge upon local societies the importance of offering special prizes for collections of wheats of proved value as rust-resisters ; and it is further advised that these collections be kept separate from the general wheat exhibits, and that they be plainly labelled, to the end that a wide publicity be given to the general subject, as well as to the characteristics of promising sorts.

Trial of Various Wheats.

3. This Conference believing that no such cereal as rust-proof wheat has yet been discovered, but that, as shown from experiments lately carried out, by importing different varieties from countries outside the Australian Colonies, and by carefully selecting and crossing them within the Colonies, certain kinds have been found to constantly escape to a considerable extent the ravages of this pest, recommends a continuance of this work of importation, selection and crossing, with a view to securing varieties most likely to escape rust and specially adapted to the different districts of our Colonies. And it having been found from evidence submitted to this Conference that certain varieties of wheat, believed to be rust-resisting when grown in one locality, have succumbed to this pest when grown in another locality, this Conference considers that while it would not be justified in specifying any particular varieties as possessing rust-resistant qualities under all conditions, nevertheless particularly recommends the following in the order given as worthy of being grown on a large scale :—

A.—*Recommended for Growing on a Large Scale.*

I.—As rust-resistant—
(1) Blount's Lambrigg, (2) Leak's, (3) Belotourka,* (4) Ward's Prolific, Marshall's White, Canning Downs Rust-resistant, Marshall's 3, Marshall's 8, Defiance.

* Belotourka is specially recommended for hot districts, either in the interior or on the coast.

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II.—As prolific and moderately resistant—
Talavera.

III.—As rust-escaping if sown early—
(1) Allora Spring, (2) Early Para, (3) Hudson's Early Purple Straw, (4) Early Baart, (5) Velvet Pearl.

IV.—Quick-maturing wheats for late sowing—
(1) Allora Spring, (2) Velvet Pearl, (3) Canning Downs Rust-resistant, (4) Early Baart.

B.—*Recommended for further Trial on a Small Scale.*

I.—As rust-resistant—
(1) Fluorspar, (2) Blount's Fife, (3) Fultz, (4) Tourmaline, (5) Niagara, (6) Improved Fife, (7) Anglo-Australian or Anglo-Canadian, (8) Manitoba, (9) Square-headed Sicilian, (10) Sicilian Baart, * (11) Clarke's Rust-proof, (12) Hornblende, (13) Summer Club, D'Arblay's Hungarian, Australian Wonder, Bearded Herisson, Marshall's 4, 6, 7, Hercules, Marshall's 10, 11, 33, 36, 17, 23, 26, Battlefield, Marshall's Prolific, Thomas' Rust-resistant, White Fife, Wheaton's Rust-proof.

II.—As rust-escaping—
(1) Jacinth, (2) Quartz, (3) King's Jubilee, (4) White's Velvet.

Recommendations for Government Action.

4. Resolved.—That it is desirable that a practical system for the production and distribution of rust-resisting wheats suitable to different districts should be immediately established, and that this system should, subject to modifications needed by each Colony, be conducted on the following lines:—A central station for each Colony for the preliminary testing of new wheats introduced into the colony, for the production of new varieties by cross-fertilisation and by selection, and for the distribution of suitable wheats thus obtained to representative districts of the colony, to be there subjected to a sufficient test and, if necessary, fixed in their characters by farmers and others competent for the work, and that such wheats as pass satisfactorily this test should then be distributed to the farmers around in such a manner and by such agency as would be most suitable to the conditions of each Colony. This Conference desires to place on record its unqualified approval of the course adopted by the Government of New South Wales in establishing a central wheat station and encouraging a number of farmers to grow pure seed-wheat true to name on a commercial scale.

Nomenclature.

5. Resolved.—That in connection with the inter-colonial exchange of seed now being carried on, steps be taken to continue the work of an Inter-Colonial Nomenclature Committee, and that such Committee be composed as at present, *viz.*, Dr. Cobb (Chairman), Mr. Farrer, Mr. McAlpine, Professor Shelton, Mr. Marshall, and Rev. H. E. Thompson. That one or more delegates from each of at least three Colonies shall constitute a quorum for the business purpose of this Committee.

* Sicilian Baart is recommended for coast as well as for interior districts.

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Experiments.

6. The Conference re-affirms the desirability of continuing experiments and inquiries in directions such as were indicated at the Adelaide Conference. The subjects for investigation fall under the following headings :—

(*a*) The effect, as regards rust, of manuring.
(*b*) The effect of applying lime, salt, and sulphate of iron to the soil.
(*c*) Effect of different modes of cultivation.
(*d*) Effect and economical application of drainage.
(*e*) Efficacy of burning all straw, weeds, and other plants in the infected field, and of using other disinfecting agencies with a view to destroying spores.
(*f*) Relative value of rust-shrivelled and plump seed.
(*g*) Relative value of different varieties of wheat.
(*h*) Effect, as regards rust, of different times and modes of sowing.
(*i*) Effect of different times and modes of reaping.
(*j*) Investigations regarding plants that act as intermediary hosts, and regarding all plants that are affected by rust in the different Colonies.
(*k*) Investigations as to the earliest stage of wheat in which the fungus may effect an entrance.
(*l*) Investigations regarding any insects, such as the recently discovered grubs of a *Diplosis*, which feed upon rust-spores and may be instrumental in spreading the pest.
(*m*) Investigations in regard to the influence on rust of interchange of seed between suitable localities.
(*n*) The influence which the growing of seed in hot climates has on the early maturing of wheats.
(*o*) Investigations in regard to the effect of mixture of seed in the development of rust.
(*p*) Microscopical and chemical examination of varieties of wheat in order to discover the characteristics of rust-resisting wheats.
(*q*) That in expressing the rustiness of a wheat plant it is desirable to state whether the rust occurs on the flag, sheath, or stem ; and that the amount of rust in any of these localities is best expressed in terms of the amount of surface covered by the rust.
(*r*) Determinations of the particular kind of *Puccinia* affecting the crops in different districts and the damage done by each.
(*s*) Investigations as to the relation between the variety of wheat and the time of attack by the rust-fungus.
(*t*) Investigations to determine the presence or absence of the rust-fungus in the seed.
(*u*) Investigations concerning the ability of certain wheats to endure the rust disease without injury therefrom.

The Next Conference.

7. Resolved.—That it is desirable, in the interests of wheat-growing in Australia, that another Inter-Colonial Conference on the subject of rust-resistant wheats and their milling qualities be held two years hence under the auspices of the various Governments, and that such Conference be composed equally of wheat-growers, millers, and scientific

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App. C. iv. men having a knowledge of wheat and its diseases; and it is further recommended that the meeting above recommended be held in Melbourne, Victoria.

Publication of Reports on Experiments.

8. RESOLVED.—That it is desirable that reports of the coming season's inquiries and experiments in each Colony be published by the respective Governments in the ordinary departmental publications, and that an inter-colonial exchange of these reports be effected in the usual way.

Brisbane; 28th March, 1894.

V.—REPORT OF COMMITTEE, FIFTH CONFERENCE.

App. C. v. This Conference proposes to inform the public of the progress of investigations bearing on the problem it has now in hand, and offers a statement of the conclusions at which it has arrived. The Inter-Colonial Conference on Rust in Wheat was originally convened by the Government of Victoria in 1891, and it was then thought desirable that, if possible, light should be thrown on the problem—

(1) by researches into the Life-History of the fungus causing the disease popularly known as rust;
(2) by a careful study of the different varieties of wheat;
(3) by a varied series of experiments in the cultivation and treatment of wheat;
(4) by compiling the experience of practical farmers.

In succeeding years Conferences were held at Sydney, Adelaide, and Brisbane respectively, and at each the experiments up to date were discussed, new facts were brought forward, and the problem gradually simplified.

To give some indication of the vast extent of experimental work which members of the Conference have conducted during the period that has elapsed since the first Conference adjourned, the following may be mentioned as some of the many subjects of experiments :—

(1) The relations of applied manures to the prevalence of rust.
(2) Effect of different systems of cultivation.
(3) The character of the flag and straw of wheat as influencing the spread of the disease.
(4) The extent to which the rust spores adhere to seed wheat.
(5) Microscopical, chemical and milling characters of wheat and baking tests of their flours to determine the relation of rust-resistance to other qualities.
(6) The relative merits of different varieties of wheat, especially their rust-resistant properties.
(7) The creation of rust-resisting sorts by cross-fertilization and selection.
(8) The relation of hardness and softness of grains to rust-resistance.
(9) The relative rust-resistance of plants from large and small grains.
(10) The relative yield from plump and rust-shrivelled grains.
(11) The relative earliness of crops grown from seed consisting of large and small grains respectively.
(12) The relative earliness of plants from plump and rust-shrivelled grains respectively.

(13) The relative germinating power of plump and rust-shrivelled grains.
(14) The effect on earliness of the application of different manures.
(15) Improvement in milling qualities by selection and crossing.
(16) The effect of fungicides applied by spraying growing crops.
(17) Influence of insects as carriers of rust spores.
(18) Determination of the particular kinds of rust affecting crops in different districts, their life-histories and their effects on the host plant.
(19) Effect in relation to rust of different times and modes of sowing wheat.
(20) The practicability of disinfecting and cleaning threshing machinery by means of live steam.

Reflection will show that all these lines of experiment have a direct bearing on the rust problem. Numerous other experiments having a less obvious but still fairly direct bearing on the question have also been made but are not recorded here. Most of these experiments are such that reliable conclusions cannot be reached from one year's work. Indeed many of them will require to be carried on through a period of years, but when results are available they will be published by the Department of Agriculture of the Colony in which the results have been obtained.

The Conference believes, however, that already great good has come from meetings held in past years and recognises with much satisfaction that farmers in the several Colonies now pay more attention to the varieties of wheat: that many sow at least a part of their area with rust-resisting sorts; that there is more desire to obtain wheats true to name, and that many of the suggestions or recommendations of former Conferences, such as the desirability of sowing early in the season and the selection of early maturing varieties of wheat are now being acted on widely.

The Conference recognises further that through its influence farmers in wheat-growing districts in these Colonies have a choice of rust-resistant varieties of wheat capable of giving good average yields and of good milling quality.

Of scarcely less importance to the wheat-growing interests are the indirect results of the labors of this Conference. It may be said with entire truthfulness that the important results shown by the experiments of the different Colonies as carried out by members of this Conference have given an impetus to wheat culture in several of the Colonies at a time when disease and low prices had brought the business of wheat growing into general disrepute. It has been shown in the course of these experiments that the Australian Colonies are very favourable to the growth, in great variety, of the best and most nutritious wheats. The experimental stations have been centres from which new and improved varieties have freely passed to wheat-growing areas in all the Colonies. In this manner the suitableness of different sorts to the varying conditions of soil and climate covered by these investigations have been demonstrated, and knowledge of the capacity of the country for wheat-growing extended. These and other results not altogether germane to the original purpose of the Conference have grown out of its deliberations.

A prominent obstacle this Conference has met with has arisen from the objections of millers to rust-resistant wheats, and the adoption of such varieties has for that reason been retarded. We recognise

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that the dislike of these millers for rust-resistant wheats, as such, has had legitimate foundation in the past: for a large section of such wheats—the one section, in fact, in which rust resistance is a prominent and normal characteristic, consists of the maccaroni wheats which from the inferiority of the colour of the flour they yield and from its relative deficiency in strength (although not in gluten) are entirely unsuitable for the making of attractive and light bread, while their excessive hardness causes them to be difficult to grind. Many millers have doubtless experienced disappointment and loss from purchasing these wheats. Such objections, however, are entirely inapplicable to the wheats this Conference is prepared to recommend to the farmers as rust-resistant; they are not maccaroni wheats but bread wheats, and possess none of the undesirable qualities which are attached to the maccaroni section of resistant wheats; many of them, in fact, belong to the very sections in which are the wheats from which the best Hungarian and Minnesota flours are made, and these flours are considered to be among the very best in the whole world. Dr. Cobb's examination also of the relative hardness of wheats grown at the Wagga Experimental Farm (which, by the way, possesses conditions of soil and climate which are very fairly representative of the great bulk of the wheat-growing country of New South Wales, Victoria and South Australia) shows that the wheats we are prepared to recommend are many of them even softer than those which the millers are recommending to the farmers, purchasing readily and grinding every day; while Mr. Guthrie's practical examination of them with a roller mill has shown that stronger, more nutritious, and as attractive flour can be made in as large quantity and with as little trouble from a given quantity of most of them, as can be won from the largest, whitest, and most rust-liable wheats the millers view with approval.

The opinion this Conference has long held is, that the opposition of millers to such wheats has no legitimate foundation, but arises either from misconception or from conservatism; for the reasons which have been given above this opinion has become a conviction, and this conviction the Conference wishes to make public in this report with emphasis and without reservation.

The Conference considers the continuance of the work of the Nomenclature Committee of much importance, and especially that portion of its work which deals with the grouping of varieties of wheat according to the degree with which rust is resisted. No rust-proof wheat, properly so called, has so far been shown to exist, but there is no doubt that wheats vary very widely in their liability to rust. The terminology hitherto adopted has been found very suitable, and it is thought well that it be maintained and that wheats be grouped as follows:—

I.—Rust-resistant Wheats, such as Defiance and Ward's Prolific, which resist either the entrance of the mycelium into their tissues or its subsequent growth and out-burst.

II.—Rust-escaping Wheats such as Allora Spring, Early Para and Early Baart, which, though rust-liable, yet when sown early or in good time, ripen before the season is sufficiently advanced for rust to be propagated rapidly.

III.—Rust-liable Wheats, such as Golden Drop, Red Straw and Purple Straw, which very readily succumb to rust.

The wheats grouped in the first class are characterised (1) by the thick or tough skin of the plant—so tough that, although the rust mycelium

may enter the plant by means of the stomata, yet it cannot break through the skin in order to mature and shed its spores, and accordingly its further development is prevented, or (2) by the presence of a waxy exudation on the surface of the plant similar to the bloom of fruit, which when present about the stomata prevents the rust mycelium from entering. Wheats possessing both these characters may be grown under all conditions suitable to their normal growth without suffering seriously from rust.

The second class of wheats does not invariably escape rust, yet the burden of evidence available to the Conference goes to show that in the majority of instances, if sown early, these wheats will escape serious damage. Even later wheats, such as Talavera or White Lammas, if sown very early, may escape rust in a season favourable for it.

The Committee with the suggestions of former Conferences before it, and in the light of new evidence and information which this Conference has elicited, recommends that the following conclusions and resolutions be adopted by the Conference :—

A.—*Recommendations to Farmers.*

Although no effective or unfailing means of preventing rust in wheat can be advanced, this Conference is of opinion that the risk of loss from the fungus may be lessened in a very marked degree by the general adoption of the following recommendations wherever practicable :—

(1) That early-ripening varieties be cultivated as extensively as practicable with reference to the exigencies of harvesting.

(2) That early sowing, more especially of the later sorts, be adopted whenever practicable.

(3) That early-sown crops be planted thinly with due regard to the habits of tillering of different varieties and the local conditions of soil and climate.

(4) That those varieties of wheat which experience has shown to be rust-resisting or rust-escaping, be grown much more extensively with due regard to market value.

In this connection the following wheats are recommended :—

(*a*) As *Rust-resistant.*—Ward's Prolific, Marshall's 3, Marshall's 8, Australian Wonder, Robin's Rust-resistant. For cooler districts,—Defiance wheats such as Wheaton's R.R., Blount's Lambrigg, Pringle's Defiance, Tunnack, Smith's Nonpareil. For cooler and moister districts, fine wheats such as Improved Fife and Hornblende.

(*b*) *Rust-escaping.*—Allora Spring, Budd's Early, Early Para, Canning Downs RR., Early Baart. When late sowing is inevitable, these wheats are very strongly recommended to be sown.

(*c*) *Prolific and Moderately Resistant.*—Talavera, Leak's White Lammas.

The Governments of the several Colonies represented at this Conference have a number of promising rust-resistant varieties under trial ; and are in a position to distribute to farmers, who may wish to test them, small samples of those which have given the best results. Farmers who are able to try new sorts are recommended to do so, and to make application to the Government of their own Colony for small samples of sorts which have given specially promising results in it.

(5) When sowing is unavoidably late, not only should early varieties be used, but these should be accompanied by phosphatic

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manures in order to hasten the maturity of the plant and lessen the risk of rust, as well as to increase the yield.

(6) That a change from the Purple Straw wheat, now so generally sown, to wheats of the White Lammas and Talavera types, more especially in the Colonies of South Australia, Victoria, and New South Wales, is desirable.

(7) Whenever large quantities of foreign wheat are available for seed from a climate differing essentially from that of these Colonies, it is considered hazardous for farmers to sow them on a large scale, however desirable it may be to sow them on a small scale for experiment.

The Conference further puts forward the following conclusions at which it has arrived :—

(1) It is of opinion that there is no possible treatment of the seed that will protect the plants growing from it from the attacks of rust.

Furthermore, that the notion that rust-shrivelled seed can be sown with as good results as plump seed is erroneous.

Of the many practical details which have been demonstrated experimentally as calculated to diminish the prevalence of rust, the Conference emphatically recommends the following :—

(*a*) That seed wheat be allowed to ripen fully and be carefully stripped or threshed.

(*b*) That seed wheat be graded and the larger and heavier grains selected for seed.

(*c*) That the utmost care should be adopted to ensure that the varieties of wheat selected for seed be pure and true to name.

B.—*Recommendations for Government Action.*

Seed Wheat.

Resolved.—That it is desirable that a practical system for the production and distribution of rust-resisting wheat suitable to different districts should be maintained and perfected, and that this system should, subject to modifications needed by each Colony, be conducted on the following lines :—Stations in wheat-growing districts in each Colony for the preliminary testing of new wheats introduced into the Colony, for the production of new varieties by cross-fertilisation and by selection, and for the distribution of suitable wheats thus obtained to representative districts of the Colony, to be there subjected to a sufficient test and, if necessary, fixed in their characters by farmers and others competent for the work, and that such wheats as pass satisfactorily this test should then be distributed to the farmers around in such a manner and by such agency as would be most suitable to the conditions of each Colony. *This Conference desires to repeat and emphasize its unqualified approval of the course adopted by the Government of New South Wales in establishing a central wheat station and encouraging a number of farmers to grow pure wheat-seed true to name on a commercial scale.* The results

which have already been secured in that Colony are such as to justify its emphasizing this approval. App. C. v.

NOMENCLATURE COMMITTEE.

RESOLVED.—That in connection with the inter-colonial exchange of seed now being carried on, steps be taken to continue the work of a Nomenclature Committee, and that such Committee be constituted as follows:—Dr. Cobb (Chairman), Mr. Farrer, Mr. McAlpine, Professor Shelton and Professor Lowrie. That one or more delegates from each of at least three Colonies shall constitute a quorum.

RESOLVED.—That in view of the desirability of the effective continuance of the work of solving the rust problem, it will be well that the work of the Nomenclature Committee be extended, and that to it be committed this task as well as that of from time to time making such recommendations to Governments of different Colonies as it, as a body, considers will advance the wheat-growing industry.

EXPERIMENTS.

This Conference re-affirms the desirability of continuing experiments and enquiries in directions such as are indicated in previous paragraphs of this report dealing with experimental work.

Melbourne, May 1896.

F. 725.

G. I. C. P. O.—No. 252 R. & A.—25-11-97—2,240

(Vegetable Product Series, No. 36.)
(Fibres.)

THE AGRICULTURAL LEDGER.

1897—No. 17.

CALOTROPIS PROCERA.

(SILK-COTTON—FLOSS.)

[*Dictionary of Economic Products, Vol. II.*, C. 191-7.]

SILK-COTTON (FLOSS) OF CALOTROPIS PROCERA.

Reports on the Fibre by MR. C. F. CROSS, *Scientific Referee on Fibres, and* MR. C. E. COLLYER, *Practical Expert Referee at the Imperial Institute, furnished through* SIR F. A. ABEL, BART., K.C.B., *Honorary Secretary and General Director.*

HISTORY of ENQUIRY.

In 1894 the authorities at the Imperial Institute asked (in letter No. 28 F. S. S., dated 17th July) to be supplied with certain fibres including the bark fibre of **Calotropis procera.** The request was duly dealt with, and registered (No. 43) for action during 1895-96.

Repeated enquiries had been made for the floss or silk cotton of the seeds. Among the samples hitherto received by this office, some uncertainty existed as to whether the *Akunda* floss supplied had been obtained from **Calotropis procera** or **C. gigantea.**

It was accordingly thought desirable to take the opportunity afforded while collecting the bark fibre of **Calotropis procera** to procure the floss also, and in response to this office request a quantity was obtained through the Director, Land Records and Agriculture, North-West Provinces and Oudh, from the Superintendent, Government Botanic Garden, Saharunpur.

A portion of that supply of the floss was accordingly sent to London. The sample was submitted by the Honorary Secretary and General Director, Imperial Institute, to the Scientific Referee on Fibres, and also to the Practical Expert Referee of the Institute.

CALOTROPIS procera. **Silk-Cotton (Floss) of**

HISTORY of ENQUIRY.

Now first analysed.

As far as can be ascertained, this is the first time a chemical analysis has been made of a sample of floss or silk-cotton. The investigations of Messrs. Cross and Bevan into the constitution of fibrous substances has been of the greatest scientific interest as it has enabled the whole series of vegetable cellular substances to be classified in an intelligible manner.

Order of celluloses.

Their arrangement of the celluloses, as the result of a large number of experiments, may be given as follows :—

They are first divided into two main groups—

1. Celluloses resisting hydrolysis (chiefly fibrous).
2. Celluloses easily hydrolysed (chiefly cellular).

The first group is again referred to three sub-groups—

A.—Cotton . .	type—Cotton.
B.—Wood cellulose . .	type—Jute.
C.—Cereal cellulose ..	type—Straw.

Furfural.

One particular feature of these cellular and fibrous bodies is the relative amount of furfural yielded by them. Furfural is an oily product obtained on distilling bran with hydrochloric acid, but is afforded by all the above substances in a greater or less degree. The percentage of furfural yielded by articles of the sub-groups are—

A.	B.	C.
0·1	3·0-5·0	12·0-15·0

The quantity of furfural obtained from the silk-cotton is higher than indicated in the above list, and would suggest the inclusion of flosses in the second group, which comprises celluloses of the starch type.

Bark fibre not easily procured.

The fibre from the bark of the two species of **Calotropis,** *viz*. **gigantea** and **procera,** is being obtained for experiment. Correspondents have complained of the extreme difficulty experienced in separating the fibre in sufficient abundance and suitable condition, but a consignment is expected from the Director of Land Records and Agriculture in Madras.

The information already obtained regarding flosses is, however, of sufficient importance to justify its publication in *The Agricultural Ledger*. The facts brought to light will doubtless be of interest to those desiring to develop a trade in this class of Indian fibres. Sir F. A. Abel's letter reviewing the results of examination of the floss by Mr. C. F. Cross, Scientific Referee, and the opinion expressed

IMPERIAL INSTITUTE REPORT.

by Mr. C. E. Collyer, Practical Expert Referee, may accordingly be given in full.

From Sir F. A. Abel, Bart., K.C.B., *Honorary Secretary and General Director, Imperial Institute, London, to* George Watt, Esq., M.B., C.M., C.I.E., *Reporter on Economic Products to the Government of India, Indian Museum, Calcutta,—F. S. S. No. 119, dated London, 18th September 1897.*

"In Flying Seal letter addressed by me to you, No. 28, dated 17th July 1894, I asked that the Imperial Institute might be furnished with samples of the fibres of **Marsdenia tenacissima, Calotropis gigantea** and **Calotropis procera** 'in some quantity,' and in your letter of the 28th August of that year, you informed me that the fibres in question were registered to be dealt with in the year 1895-96. You also explained that **Calotropis procera** afforded two fibres, but that it was presumed that the *bark* fibre was the one which we desired to possess. Up to the present time we have not received a sample of the bark fibre in question, but, in June last, I received from Mr. Royle a sample of the silk-cotton (floss) of **Calotropis procera,** to which reference was made by you in your letter to him of July 7th, 1896. This floss was forwarded together with the seeds which, in the letter just referred to, you spoke of as deserving of chemical examination in consequence of the high position which the bark of the plant furnishing them stands in popular favour as a medicinal agent. The seeds were handed over to Professor Dunstan for examination, and will no doubt be shortly reported upon. The floss has been submitted by me to our Scientific Referee on fibres, Mr. C. F. Cross, who has just reported the following as the results furnished by its examination. The more important constants of the fibre which has the chemical characteristics of lignocellulose, are as follows :—

The floss: Report of Scientific Referee.

Moisture		9·0 per cent.
Ash		3·0 per cent.
Hydrolysis	Alkali	(1% N_aOH) 26·2 per cent. (loss).
	Acid	(1% H_2SO_4) 24·7 per cent. (loss).
Cellulose		69·8 per cent.
Furfural		19·5 per cent.

"Mr. Cross states that this floss fibre is an extremely interesting chemical type, containing as it does a very high and, in his experience, unique, percentage of furfural. He adds, however, that,

CALOTROPIS procera.

Silk-Cotton (Floss) of Calotropis procera.

IMPERIAL INSTITUTE REPORT.

Extensive use not probable.

although it may find use for some applications of floss fibre, its somewhat unfavourable chemical characteristics are not likely to recommend it to the spinner in view of the present low price of cotton.

The floss: Report of Export Referee.

"I have also submitted a sample of the floss of **Calotropis** to our practical expert Referee, **Mr. C. E. Collyer**, who reports as follows:—

"This particular floss was in considerable demand in the markets a few years ago for fancy textile purposes, but owing to the difficulties presented by the variations in the quality of parcels supplied, and to the intermittent supply when requirements arose, the material has dropped out of use.

The Java product stated to be superior.

The quality of the Indian growth is inferior to the product of Java, which is probably derived from **Calotropis gigantea,** small samples of which have occasionally been received from India.

Character of present sample.

The specimen now submitted is of fair colour, and of rather short staple and somewhat towy in character, containing an excessive quantity of inferior immature fibre and seed fragments.

Akund cotton: other samples described.

"He has had under his hand many varieties of the floss in question, mostly from Calcutta (where it is sometimes called "akund cotton"), which were mostly inferior to the sample now submitted to him. These samples were sold at as low a price as one penny per pound, and there was but little demand for them at that price.

Prospects of future trade.

The trade in this floss may possibly be revived if a moderate but continuous supply can be guaranteed. If of good quality, it would realise prices ranging from 4*d.* to 5*d.* per pound, c. f. and i. terms.

How the floss should be packed for export.

In packing for sale, the floss should be handled as little as possible, the pods and seeds being entirely removed and the floss left in its natural condition unopened; any discoloured portions should be separated and forwarded separately. The bales received here from Java usually contain 80 to 90 pounds of floss tightly sewn in canvas, but not pressed.

"I presume that we shall receive, as promised, samples of the *bark* fibre of **Calotropis procera,** as its chemical examination is of interest in view of the popularity of the bark as a medicinal agent."

C. 191-7.

G. I. C. P. O.—No. 480 R. & A.—1-12-97.—2,000.—J. C.

(Entomological Series, No. 7.)

THE

AGRICULTURAL LEDGER.

1897—No. 18.

TERMES TAPROBANES.

(WHITE-ANTS.)

[*Dictionary of Economic Products, Vol. VI., Pt. I.*, P. 434.]

WHITE-ANTS AS A PEST OF AGRICULTURE.

A Note by the Settlement Officer of Balaghat, Central Provinces, prefixed by certain passages, reprinted from the "Indian Museum Notes", on termites in relation to crops, etc.

Introductory.

The correspondence herein reviewed on the subject of damage to plants by white-ants in the Central Provinces is reproduced with permission of the Commissioner of Settlements and Agriculture, Central Provinces.

As a useful introduction to the information thereby furnished, the following particulars of the Pest, taken from the '*Indian Museum Notes*', may be given.

White-ants in Chota-Nagpur.

Volume I, Page 63.—"White-ants—Sugar-cane in the Giridhi Sub-division, says the officer in charge of it, is especially liable to the attack of this insect. The Manager of the Chota-Nagpur Raj says that its mode of attack is to eat up the root of live crops and cause the plants to die. The ryots, he says, are not acquainted with any remedy for it." *C. C. Stevens, Commissioner of Chota-Nagpur, Report dated 26th October 1888, Office of Director of Land Records and Agriculture, Bengal.*

"The Personal Assistant to the Director of Land Records and Agriculture, North-Western Provinces, notices in a report dated 30th

PESTS.

White-ants as a Pest

INTRODUCTORY.

White-ants in Cawnpur.

April 1888 that, until the sugar-cane borer (**Diatraca saccharalis,** *Fabr.*) appeared near Cawnpur, white-ants had been found to be the most serious pest with which sugar-cane had to contend, though they could always be more or less effectively checked by heavy watering.

Volume I, Page 66.—"White-ants, said to attack the roots, and at times the stems of young plants of all sorts of crops, especially paddy, jute, and *arhar*, also all vegetables, sugar-cane, and big trees; also rice in granaries, timber in buildings, and books in almirahs. They are said to disappear from the roots of crops when heavy showers fall, but never to disappear from the roots of trees."

Nadia.

"These are white-ants TERMITES (**Neuroptera**)." (Report from Collector of Nadia forwarded to the Indian Museum by the Director of Land Records and Agriculture, Bengal, see his letter No. 149, Agriculture, dated Calcutta, 17th January 1889.)

Common white ant described.

Volume II, Page 172, Para. 230.—"**Termes taprobanes**, *Walker*. The common white-ant of Lower Bengal. Very destructive to inferior timber and other dried vegetable matter, also attacking young and unhealthy plants. It is likely to be the species which has been reported as injuring sugar-cane (**Saccharum officinarum**) in Cawnpur. . .

White-ants in Gujarat.

Volume IV, Page 36.—"**Termes taprobanes**.—The white-ant is very destructive on the light sandy soil of Northern Gujarát.

"It attacks most crops after they are cut and stored, and hay, corn-stacks, etc., must be carefully watched. Corn is always threshed soon after it is cut for fear of white-ants entering the stack.

How sugar-cane is attacked.

Remedy.

Mode of application.

"Sugar-cane suffers severely from white-ants. They burrow into and destroy the sets soon after planting, and eat through the junction between the young plant and the parent set, so that the latter withers off. The remedy always employed is castor-cake. Cultivators apply the powdered cake to the roots of the cane, two or three times between May and August. The total quantity given in a season is usually between 1,500lb and 2,000lb per acre. This large application of castor-cake is of course chiefly given as a manure, and not to keep off white-ants, but it serves two purposes very effectively." (Report, dated 10th August 1894, by Prof. J. H. Middleton, Baroda College, forwarded by the Survey Commissioner and Director, Land Records and Agriculture, Bombay.)

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White-ants as a Pest of Agriculture.

WHITE-ANTS IN THE CENTRAL PROVINCES.

From L. S. Carey, Esq., I C.S., *Commissioner of Settlements and Agriculture, Central Provinces, Nagpur, to the Reporter on Economic Products to the Government of India, Calcutta, No. 1668—126, dated Nagpur, the 22nd May 1896.*

I have the honour to enclose copy of a note, dated 2nd May 1896, by the Settlement Officer of Balaghát, on the damage caused to young plants by white-ants, and to enquire if any efficacious and cheap remedy has been discovered in any other part of India for the prevention of the destruction of trees by termites.

I should be obliged by any information on the subject.

Copy of a Note, dated 2nd May 1896, from the Settlement Officer, Balaghát, to the Commissioner of Settlements and Agriculture, Central Provinces.

Note by Settlement Officer, Balaghat. Mango saplings often attacked by white-ants.

White-ants are especially fond of young mango trees. In some villages repeated efforts to make a mango grove have failed on account of the roots of the young trees being attacked by white-ants. I once doubted this fact and was disposed to believe that in those villages the people were unusually negligent in watering the saplings, and that first the trees died of thirst and then the white-ants devoured the dead wood, as is their ordinary practice. A scientific forester had told me that white-ants attacked only dead wood, and hence my scepticism as to the statements of the villagers; but I am now convinced that the saplings in many cases die of white-ants and not of other causes, that the attacks of the white-ants on the roots are the cause and not the effect of the trees drying up.

Statement that white-ants will not attack living trees.

The cause that led me to this perception of the truth is that I have attempted to raise a row of half a dozen mango trees close behind my bungalow, and I have had a number of the saplings die, they being in most cases attacked by white-ants. I have dug up three of the trees in different stages of the white-ant disease. One of the plants was almost dead, and it would have been difficult to prove that the white-ants were not innocent scavengers, removing useless dry wood. Another tree was half-dead, and the theory that exonerates the white-ant from the charge of devouring living timber could only be maintained by crediting the termite with a marvellously accurate prophetic instinct that told the scavenger which of the trees were already

Disproved by experiment.

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PESTS. **White-ants as a Pest**

WHITE-ANTS IN THE CENTRAL PROVINCES.

doomed to die and might be removed as useless, for the tree was not yet dead but only likely to die shortly. In the third case the tree still looked quite green, save for a suspicion of unhealthiness about some of its leaves, and on digging it up I found that its roots had been eaten through in places by white-ants, and that a detachment of the voracious termites was actually pushing its way up the heart of the sapling, eating its path through perfectly good, juicy wood. The sight of a channel about $\frac{1}{8}$th of an inch wide thus eaten out up the very centre of a sapling appeared to me to be conclusive proof that the mango tree was dying from the attacks of white-ants pure and simple, and that the theory I had heard put forth in the name of Science by a Forest Officer was untenable. That theory appears to me to confuse two cases: (*i*) that in which white-ants attack young trees a few feet high, eating out the heart of the tree, full of sap though it is, and doing their work of destruction unseen below the surface, and (*ii*) that in which white-ants ascend the *outside* of a tree in search, presumably, of dead branches on top.

Result of experiments to ascertain whether living trees are subject to attack by white-ants.

The attacks of the first of the above kinds are not confined to young trees. I have found fields of *tur* in which a number of the plants have withered owing to the roots being eaten up by white-ants and in gram fields also I have had similar damage pointed out to me.

If, then, it be considered as proved that white-ants do considerable damage to horticulture by attacking the roots of living trees, the question of finding some preventative against their ravages becomes one of practical importance. I have made enquiries as to remedies against the attacks of termites, and found that the popular preventatives are numerous and not usually efficacious.

Remedies considered.

The cultivator starts with the belief that the white-ants have a delicate sense of taste or smell, and exercise their ingenuity in inventing nauseous mixtures with which to water the suffering plant. Water in which fish has been allowed to decompose is believed to be almost as strong in efficacy as in stench. Solutions of salt or tobacco are about the most popular of remedies. The *ál* dye I have heard of in this connection, but it is not thus used locally. The burying of *gúr* in a hole near the tree, in the hope that black-ants will be attracted thereby and will incidentally eat up the white-ant colony, has been put forward by villagers. I have also been told to utilize the fact that bears are greedy eaters of white-ants, and to soak a bear-skin in water

Conf. Agricultural Ledger No. 9 of 1895, p. 4.

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WHITE-ANTS IN THE CENTRAL PROVINCES.

and put the termites to flight by applying the resulting liquor, highly impregnated with the smell or taste of their enemy's skin.

None of these proposals are believed in very much by the people. I have myself tried a decoction of salt and tobacco with some effect, but the young trees are not thriving on the diet any more than the white-ant is. The question of finding a cheap and efficacious remedy is, I submit, worth an enquiry over a larger area than I have been able to arrange for.

From George Watt, Esq., M.B., C.M., C.I.E., *Reporter on Economic Products to the Government of India, to the Commissioner of Settlements and Agriculture, Central Provinces, Nagpur, No. 1716—222 A., dated the 10th June 1896.*

I have the honour to acknowledge the receipt of your letter No. 1668—126, dated the 22nd ultimo, and to thank you for copy of a note therewith enclosed from the Settlement Officer of Balaghát on the subject of damage caused to young plants by white-ants. With your permission the note will be published at some future time in a review of correspondence on the subject.

2. In reply thereto I have pleasure in forwarding herewith a section of my Report on Tea Blights relating to white-ants. On page 11 of that paper is described a preparation, Gondal Fluid that is believed to be a useful preventive.

3. As the preparation is still in a measure on its trial, I shall be deeply obliged for the results of any experiments which you may direct to be made with the Fluid.

4. I may add that it is believed all tbe ingredients may be procured from the bazar.

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G. I. C. P. O.—No. 483 R. & A.—16-4-98.—2,200.—J. J. S.

(Medical and Chemical Series, No. 11.)
(Medicinal Products.)

THE
AGRICULTURAL LEDGER.
1897—No. 19.

ACONITUM FEROX, A. FEROX, *var.* CRASSICAULIS, AND A. NAPELLUS.

(THE ROOTS.)

[*Dictionary of Economic Products, Vol. I.*, A. 397, 413.]

THE CONSTITUENTS OF SOME INDIAN ACONITES.

A Report by PROFESSOR WYNDHAM R. DUNSTAN, *Director of the Scientific Department of the Imperial Institute, London.*

The specimens of Aconite root which furnished the subject of this paper, were collected in the autumn of 1895 in response to a circular letter drawn up by the Reporter on Economic Products and sent to the Conservators of Forests of Bengal, Panjab and North-West Provinces. Professor Dunstan's work in the chemistry of the aconites having attracted considerable attention, Sir F. Abel applied to the Government of India for additional supplies of the roots to enable the investigation to be continued. The interesting series of experiments commenced in the Research Department of the Pharmaceutical Society of Great Britain and were resumed in the laboratories of the Imperial Institute on the reorganisation of the Scientific Department. Several papers on the subject have appeared in the *Journal of the Chemical Society*. The main features of the research have been the examination of the roots of **Aconitum Napellus** and an enquiry into the constitution of its alkaloid, aconitine. An important publication by Dr. Jowett has appeared concerning the root of **A. heterophyllum** and its active principle, atisine. Preliminary notices have

Introductory Note.

Aconite Research.

A. heterophyllum.* See *Agricultural Ledger No. 32 of 1896.

also appeared (*Journ. Chem. Soc.*, March, 1897,) with regard to **A. ferox,** and its alkaloid, pseudaconitine, and an accurate method has been devised for the estimation of the alkaloid in the root.

Aconitum ferox.

A. ferox, *Wall.*, grows in Himalayan localities from Sikkim to Garhwal at elevations of between 10,000 and 15,000 feet. The roots sent to the Imperial Institute were kindly collected by **Mr. F. B. Manson**, Deputy Conservator of Forests, Darjiling Division. The first consignment was advised on the 21st December, 1895, and consisted of roots of **A. ferox** (*Bikh*) (Reg. No. 6812) and roots of *Kalo Bikhoma* (Reg. No. 6813) identified as a variety of **A. ferox,** *var.* **crassicaulis** (—A form described in *Monograph on Certain Rare Plants of the Ranunculaceæ, by P. Brühl, Annals of Royal Botanic Garden, Calcutta, Vol. V., p. 110*). In January, 1896, the remaining quantities of the same collection were sent to this office by the Deputy Conservator and as these were accompanied with botanical specimens they had assigned to them separate registration numbers. They consisted of the roots *Bikh* (Reg. No. 7037) and *Kalo Bikhoma* (Reg. No. 7038). But the discrepancy pointed out by **Professor Dunstan** in the chemical composition of two sets of roots, supposed to have been identical, led to a fresh enquiry. In consequence it has been found that a mistake had been made by the contributor in subsequently assigning the numbers one, two and three in a different sequence to that given in the first consignment. In consequence No. 6812 was found by **Professor Dunstan** to differ materially from, instead of being identical with, 7037. Further Nos. 7037 and 7038 were found to be identical instead of independent forms. But now comes the most curious part of the enquiry. **Professor Dunstan's** investigations identify the variety **A. ferox** *var.* **crassicaulis,** Nos. 7037 and 7038, as the drug hitherto recognised, and the typical form of the species **A. ferox** (No. 6812) as containing a crystalline compound not hitherto known.

A. ferox var. crassicaulis.

It is thus satisfactory to learn that, so far as the enquiry has progressed, the botanical isolation of the variety **crassicaulis** is confirmed by the chemical results obtained.

Since receipt of **Sir F. Abel's** letter below, the botanical specimens corresponding to the above roots have very kindly been examined by **Drs. King** and **Prain** and the identifications critically confirmed. But in order to allow of a more complete enquiry steps

have been taken to obtain further supplies of the two Darjeeling forms A. ferox and A. ferox *variety* crassicaulis.

From Sir F. A. Abel, Bart., K.C.B., *Honorary Secretary and General Director, Imperial Institute, London, to* George Watt, Esq., M.B., C.M., C.I.E., *Reporter on Economic Products to the Government of India, Indian Museum, Calcutta,—No. 120 F. T. S., dated London, 30th October, 1897.*

I have the honour to forward, herewith, a second Report by Professor Dunstan, the Director of the Scientific and Technical Department of the Imperial Institute, on certain results furnished by investigation of the constituents of some Indian Aconites; and I would direct attention to the suggestion that a further supply of the roots of Nepaul Aconite (Aconitum ferox) is desirable, with a view to the fuller examination of the crystalline alkaloid which has been extracted from one specimen. Further samples of the roots of Aconitum Napellus might, as Professor Dunstan points out, be furnished with advantage.

Report by the Director of the Scientific Department on the Constituents of some Indian Aconites.

In continuation of previous investigations, already reported (Report on Aconitum heterophyllum, dated 25th July, 1896; Second Quarterly Report to the Indian Committee, dated 7th January 1897; Annual Report to the Indian Committee on Investigations conducted for the Government of India, for the year ending 1st April, 1897; letter No. 116 F. S. S., dated July 22nd, 1897) of the constituents of the various Aconites occurring in India, a qualitative and quantitative examination has been made of the alkaloids contained in specially collected samples of the roots of Nepaul Aconite (Aconitum ferox) and of Aconitum Napellus, which have been received from the Reporter on Economic Products to the Government of India (letter No. 1369—116 F. S. S., from Reporter on Economic Products, dated May 13th, 1896). Previous Investigations.

Nepaul Aconite (Aconitum ferox).—Five samples of roots have been examined, one from the Punjab, the other four from Bengal. With the exception of one of the latter specimens (No. 6431), all these roots furnished a crystalline alkaloid which corresponded in every respect with the highly poisonous *A. ferox* and pseudaconitine.

'pseudaconitine' of which an account has been already published by Mr. F. H. Carr and myself (*Journal of the Chemical Society, 1897*). A further description of the properties and physiological action of this alkaloid will shortly be communicated.

A peculiar alkaloid.

A crystalline alkaloid was extracted from one specimen of roots (No. 6812), certain properties of which do not exactly correspond with those of pseudaconitine. If a further supply of these roots can be procured, I should like to examine this alkaloid more fully.

Estimation of alkaloid.

The quantity of pseudaconitine contained in each sample has been estimated by a process which consisted in the extraction of the alkaloid and the separation from it by hydrolysis of the veratric acid; by these means the following results were obtained :—

Indian Invoice Number.	Imperial Institute Number.	Name.	District.	Percentage of Alkaloid.
6806	7149	A. ferox . . .	Bashahr through the Conservator of Forests, Panjab.	·40
6813	7151	A. ferox, *var.* crassicaulis.	Through the Deputy Conservator of Forests, Darjiling, Bengal.	·41
7037	7153	A. ferox . . .	Ditto ditto .	·39
7038	7154	A. ferox, *var.* crassicauils.	Ditto ditto .	·50
6812	7150	A. ferox . . .	Ditto ditto .	·35

Large proportion of pseudaconitine.

These results are interesting in revealing a larger percentage of pseudaconitine than has hitherto been supposed to occur in the roots of this plant, in one case as much as half per cent. being present. These roots, therefore, contain a larger proportion of pseudaconitine than the roots of the closely allied **Aconitum Napellus** contain of aconitine.

The investigations which are being conducted by the Scientific Department render it probable that Nepaul Aconite and its active alkaloid, pseudaconitine, will prove to be as valuable medicinally as the **Aconitum Napellus** and its active alkaloid, aconitine, which are now almost exclusively employed in Europe. At present there is no large demand for Nepaul Aconite in the English market, chiefly because of the uncertainty which has hitherto surrounded the nature of its constituents and their precise medical action; even the exact source of Nepaul Aconite is not yet settled; although the plant is usually regarded as **Aconitum ferox,** there is some

Source of Nepaul Aconite not defined.

reason for doubting whether this is the case. I hope that the attention of the Botanical Survey of India will be directed to this question.

Aconitum Napellus.—The one sample (6803) of the roots of this plant came from Kaghan, Panjab. On examination the roots were found to contain the same constituent, aconitine, as the plant furnishes when grown in Europe. The proportion of this alkaloid in the present specimen is very small, and the sample compares unfavourably with the roots of European origin which appear in the English market.

A. Napellu a poor sample.

I shall be glad to receive for examination specimens of the roots of these two plants from other districts of India, and also of the roots of any other species or varieties of aconite than those with which we have already been supplied.

A further report will shortly be made on the examination of the later series of aconite specimens received in June, 1897, including a preliminary account of the constituents of **Aconitum palmatum.**

A. 397-413.

G. I C. P. O.—No. 650 R. & A.—31-1-98—2,200.

(*Vegetable Product Series, No. 37.*)

(*Dyes and Tans.*)

THE

AGRICULTURAL LEDGER.

1897—No. 20.

(*Reprint from Central Provinces Bulletin No. 2.*)

AL DYE—MORINDA.

[*Dictionary of Economic Products, Vol. V., Pt. I.,* M. 651-716.]

AL CULTIVATION, DYEING AND PRINTING IN THE CENTRAL PROVINCES.

Note by MR. R. S. JOSHI, *Superintendent, Nagpur Experimental Farm, specially deputed by the Commissioner of Settlements and Agriculture, Central Provinces, to investigate the subject in the rural districts of Nagpur.*

Agreeably to the instructions contained in Commissioner's letter No. 4057—163, dated 20th November 1896, I proceeded on tour on the 10th December 1896 to the places where *Al* is being cultivated which are Kalmeshwar, Saoner, Saorgaon, Narkhed, Patansaongi, and Khapa. **Origin of present inquiry.**

2. The villages in the Kalmeshwar Circle, where *Al* is found under cultivation, are Koosumbi, Waduna, Khurda, Ubali, Kapri, Saoner, Gujarkhedi, Dudhbardi and Saongi. The villages of Belona, Narkher, Pilapur, Pardi were famous for *Al* cultivation some ten years ago. In these places a few remnants of old trees of *Al* are found here and there on the borders of the fields in a neglected state. A large number of trees are cut up every year for fuel by the cultivators, and the fields are prepared for *juar* and other crops. The places where cloth is dyed are Patansaongi, Kalmeshwar, Saoner, Narkhed and Saorgaon. These places are situated near a river with running water, and have, therefore, become the seats of this industry as water is required in large quantity for dyeing cloth. All dyers use the Aniline **Localities where *Al* is cultivated.**

MORINDA. **Al Cultivation, Dyeing and Printing**

CENTRAL PROVINCES.

colours, and not *Ál*. All of them are in a critical state, owing to the competition amongst themselves for selling their dyed cloth at a cheaper rate. The customers hesitate to pay a high price for cloth dyed with *Ál*, and prefer to purchase at a cheaper rate cloth dyed with Aniline dyes, although these colours fade in a very short time.

Cultivation of *Ál*.

3. *Ál*, which is cultivated in the villages mentioned above, is sold by the cultivators to traders who take it to Mohali, a village in the Bhandara District, Tumsar, Andhalgaon, Gihora, Mehediwada, Seoni, Katori, and Benni. They told me that this *Ál* is used for colouring yarn in those places. A trader from Pandharia in the Bilaspur District took 20 *bojas*, costing R600, in 1896 from a cultivator of Saoner, by name Dharma Parasram, a *Lodhi* by caste and residing at Saoner. The yarn dyed with *Ál* is used by the Mahar weavers to serve as red borders for *saris* and *dhotis*. This cultivator, Dharma Parasram, also told me that there has been a greater demand for *Ál* during the past two years. The people have taken a liking for the *Ál* dye in preference to Aniline colours. He himself has some fields sown with *Ál* in the villages of Dudhbardi and Saongi.

Inquiry for *Ál* stated to be reviving.

4. With reference to Commissioner's endorsement No. 1433—163, dated 2nd May 1896, I submit my notes giving the information referred to in paragraphs 3 and 4 of Dr. Watt's letter.

Forms of the plant met with.

(*a*) ***Forms of the Morinda Plant found.***—The accompanying specimens represent the different forms of **Morinda** marked *Choti-ál*, *Badi-ál* and *Sironj*. *Choti-ál* is a cultivated plant two years old. *Badi-ál* is the specimen of a tree fifty years old, and its height is about 30 feet. *Sironj* is a specimen of a plant the seed of which will produce fruit in the third year.

Reg. Nos. 8908b. (Seeds 8910.)

No. 1 is a specimen of *Choti-ál* two years old, the roots of which are just fit for being dug up.

No. 2 *Badi-ál* three years old.

No. 3 *Sironj*, three years old.

8907 *b*, 8906, 8904 8905. (Seeds 8909.)

No. 4 *Badi-ál* tree 30 feet high, the circumference of the stem being 5 feet.

No. 5 specimen of *Sironj*, also a tree 20 feet high, stem 4 feet in circumference.

003 *b*.

When touring with Dr. Watt we did not come across the last-mentioned sample. When I inspected the fields sown with *Badi-ál* at Koosumbi, I found that some plants had fruit and flowers and

CENTRAL PROVINCES.

some had not. I, therefore, asked the cultivators the reason for this. The explanation they gave me was, that this form of plant which bears fruits the third year is produced from the seed of *Badi-ál* itself. I was not satisfied with this explanation, and I requested them to show me the trees from which the seed was collected. They were unable to do so, the seed being bought by them. When I arrived at Ubali I found a grove of *Ál* trees in which some trees bore fruits, and some did not. There was also a marked difference in the foliage and colour of the leaves of the tree.

***Badi-al* and *Sironj*.**

The leaves of the tree with fruit were narrow in comparison with the leaves of the tree which had no fruit, *see Sample (4 and 5)*. On enquiry I was told that the trees in fruit are called *Sironj*, and they are produced from the seed of the *Choti-ál*. The flowering season of this tree is just the same as small *Ál*, while the *Badi-ál* tree flowers in the hot weather. When the seed ripens it is collected from the *Badi-ál* tree as well as *Sironj* trees which are growing together. When this seed is sown plants known as *Badi-ál* are produced which do not bear fruit for five or six years, but the seed of *Sironj* produces seed the third year. There are, therefore, three distinct plants of *Ál*. *Choti-ál* produces seed in two years, *Sironj* in three years, and *Badi-ál* after five or seven years.

Three separate forms of *Al*.

(*b*) ***Whether abundant or otherwise.***—I have stated above that the cultivation has decreased, and therefore the fields are not in abundance. In each of the villages noted above, there are not more than 10 acres of *Āl* under cultivation.

Decline in cultivation.

(*c*) ***Whether a Shrub or a Tree, in other words, the age and height to which it grows.***—*Choti-ál*, *Sironj* and *Badi-ál*, when cultivated, are in a form of shrub from 1 to 3 feet in height. The big trees are from 20 to 40 feet in height and are, I am told, 30 to 40 years old.

Age and height which the plant attains.

(*d*) ***Seasons of flowering and of fruiting.***—*Choti-ál* and *Sironj* grown from seed bear flowers in the midddle of August and the fruits ripen in December. *Badi-ál* blossoms in May and June, and its fruit ripens in September, October and November.

Flowers and fruits.

(*e*) ***Whether the roots are collected and sold as a dye-material.***—The roots are collected and sold as a dye-stuff.

Dye.

When I visited Dudhbardi the digging up of the *Badi-ál* plants was proceeding. They were dug up by a *kudali* or pickaxe. One

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man is able to dig in one day 20′ × 10′ × 2′. When he digs and takes out the roots he separates the small roots from the big ones and places them in different baskets. The roots are sold by *bojas* which is 288lb. The value per *boja* is R25 to 40. As soon as the roots are brought home they are divided according to their size and cut up into small pieces on a block of wood and sorted into three classes—big, middling and small. Small pieces fetch a very high price as it contains more substance and less wood.

Collection and preparation for market.

When sown.

(*f*) ***Season of sowing, nature of soil required, etc.***—*Ál* seed, either of *Choti* or *Badi*, is sown at the beginning of the rains. It requiries *Mooramduyam* soil, *i.e.*, soil containing 60 per cent. of clay. The field should not be water-logged. It is sown by a seed drill lengthwise and crosswise. It is sometimes sown broadcast. The seed of *Badi-ál* being big is sown at the rate of 160lb per acre, and *Choti-ál* seed being small is sown at the rate of 80lb per acre. The seed germinates after 20 days. It requires weeding by hand after a month. Up to November or December two or three weedings take place. A bullock *hoe* cannot be worked as the seed is sown crosswise. Cattle are not very fond of eating the plants, but during the second year, care has to be taken to ward off the cattle to prevent them from trampling the young plants. *Choti-ál* occupies the field for two years, and *Badi-ál* from three to five years; but this period is extended by one or two years just as it suits the cultivator. The yield of root per acre of *Choti-ál* is 1,160lb and the yield of *Badi-ál* is double that of *Choti-ál*.

Soil. **Weeding.** **Protection of young plants necessary.** **Yield.**

(*g*) ***Whether two distinctive forms of Al exist.***—A distinction between *Choti* and *Badi-ál* exists in the places visited by me. *Choti-ál* comes to maturity in two years, and *Badi-ál* in from three to five years. *Sironj* comes to maturity in three years, but nobody sows a field of *Sironj* separately.

The forms *Choti-al* and *Badi-al*.

(*h*) ***Demand for Al.***—If a demand were created, a large quantity of *Ál* would be produced.

Supply and demand.

(*i*) ***Consumption of Al.***—The consumption of *Ál* has declined and the cultivators attribute it to a decrease in the demand. The dyers get Aniline colours cheaper, and therefore do not take the trouble of buying *Ál* roots and preparing a dye colour from them, which is a troublesome process.

Consumption.

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Position of the industry as regards cultivators, dyers and the public.

(j) Possibility of the adoption of Hummel and Perkin's method of preparing a dye-stuff.—The cultivators will not be able to prepare a dye-stuff, but if a merchant or a firm prepares it and sells it at a cheaper or at least a price equal to that fetched by Alizarine, the dyers will buy it willingly and use it for dyeing the cloth. If the demand is increased, the cultivators will produce the roots in any quantity. The superiority of the *Al* dye is recognized by the dyers as well as by the customers, but the customer is unwilling to loosen his purse, and the dyers, therefore, bring an article to the market which can satisfy the customer.

Process of dyeing.

I now proceed to give an account of the method of dyeing a cloth with *Al*. This method was described to me by Jagoba Shamoji Rangari of Patansaongi.

(1) ***First Stage.***—The first process consists in steeping the cloth in a solution of sheep's dung for 24 hours, next morning it is washed in running water and spread in the sun for drying, water being sprinkled over it about a dozen times. This process occupies one day. A sample of cloth which has passed through the above process is No. 1. The proportion of sheep dung to water is 1 to 12. Reg. No. 8914 (No. 1).

(2) ***Second Stage.***—Sample No. 1 is steeped six times in a solution consisting of sheep dung 2½lb, *papadkhar* (Sample No. 6) 5lb, castor oil 5lb and water to bring it to the consistency of a liquid, and dried six times, *i.e.*, six coatings of the above solutions are given. The above solution is sufficient to dye 100 yards of cloth. The same cloth is afterwards soaked in a soap solution six times and dried. The solution of soap for 100 yards of cloth is 1½lb Soap (Sample No. 7) and water sufficient to steep the cloth. Sample No. 2 has passed through the above processes and occupies a day or two in preparing it. Reg. No. 8912 (No. 6). Reg. No. 8913 (No. 7). Reg. No. 8915 (No. 2).

(3) ***Third Stage.***—The above sample is next washed in running water and dipped when wet in a solution of myrabolan (2½lb myrabolan powder and water sufficient to dip 100 yards,—only the skin of the fruit is taken and the seeds are thrown away). The cloth is then dried. A sample is appended marked No. 3. Reg. No. 8916 (No. 3).

(4) ***Fourth Stage.***—The cloth is again dipped in a solution of 2lb of alum and dried. No. 4 is given to this sample. Reg. No. 8917 (No. 4).

(5) ***Fifth Stage.***—Sample No. 4 is washed in clean water and dried in the sun. This piece of cloth is then dipped in a copper vessel

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containing water and 18℔ of powdered *Ál* roots. It is boiled until it bubbles, the cloth being turned up and down while boiling. The cloth after cooling is taken out of the solution and washed and dried.

Reg. No. 8918 (No. 5). This sample bears No. 5. In order to give the cloth some degree of stiffness, it is dipped in a solution of rice flour *kanji*.

(6) ***Sixth Stage***.—When the cloth is to be printed with any design, No. 3 sample is taken and printed with wooden moulds with an ink made of the following ingredients, *viz*., 2℔ gum, 1℔ red ochre (*geru*), 1℔ sample No. 8 alum, and 10℔ water. When the above substances are well mixed, they are passed through a cloth and the ink is ready for use. There are two kinds of ink—red and black. The above ingredients produce a red ink. The sample is marked 6-A. Black ink is produced thus :—Sulphate of iron 1℔, gum 1℔ and 4℔ water. The above substances are well mixed and strained.

Reg. No. 8911 (No. 8).

Reg. No. 8919 (No. 6, 6-A, 6-B).

A sample printed with this ink is marked 6-B in sample 6. This contains several kinds of printed designs with the above two inks.

(7) ***Seventh Stage***.—The printed cloth is lightly washed in clean water and dyed red by the fifth process, when *Jajams* and *Rajayis* are to be prepared. Sample No. 7 is a piece of *Jajam*.

Reg. No. 8920 (No. 7).

(8) When the cloth is to be used for *Patals* and *Saris* for wearing, the printed cloth is taken and dipped in a solution of 2℔ of powdered myrabolans and water, and then dried. It is afterwards dipped in a solution of 2℔ of alum and water, and dried. This cloth is then washed in the running water and dried, and then dyed with *Ál* dye with the fifth process. Sample No. 8 has gone through all the above processes.

Specimen No. 9 is of a plant locally called *Dhati*. The flowers of this plant are used for colouring the cloth before it undergoes the fifth process. It produces a yellow colour: by using it a smaller quantity of *Ál* roots is needed to colour the cloth. It is not necessary that cloth to be dyed with *Ál* dye should be dipped in a vat containing the above flowers. The colour obtained from these flowers is simply an adjunct.

Reg. No. 8921 (No. 8).

With reference to paragraph 3 I submit the botanical specimens of the plant in different stages of its growth :—

No. 10 *Choti-ál* plant 6 months old.

No. 10-A ditto ditto.

No. 11 *Choti-ál* 18 months old fit for digging.

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No. 11-A *Choti-ál* 18 months old fit for digging.
No. 12 *Badi-ál* 6 months old.
No. 12-A ditto ditto.
No. 13 *Badi-ál* 3 years old.
No. 13-A ditto ditto,
No. 14 *Sironj* 3 years old, found in the field of *Badi-ál* from which sample No. 13 is selected.
No. 14-A ditto ditto.
No. 15 old stumps of *Ál* growing in a *juar* field.
No. 15-A ditto ditto.
No. 16 *Badi-ál* tree 30 feet high at Obali.
No. 16-A ditto ditto.
No. 17 ditto ditto Pardi.
No. 17-A ditto ditto.
No. 18. *Sironj* tree growing side by side to No. 16 at Obali.
No. 18-A ditto ditto.

(roots) (*b*) No. 19 and 10lb *Choti-ál* roots.

No. 20, 10lb of *Badi-ál* roots in 3 bags sorted as $\frac{20}{1}$ small $\frac{20}{2}$ Reg. Nos.
middling, $\frac{20}{3}$ big. 8908.

No. 21. Sample of 5-year old *Badi-ál* roots eaten by worms but 8906.
which can be used by dyers as well. 8904.

No. 22. 10lb of *Sironj* roots. This is not sorted into grades. 8905.

No. 23. *Badi-ál* seed. 8907.

No. 24. *Choti-ál* seed. 8903.

No. (*c*) As for **Morinda umbellata,** I did not come across 8909.
the plant, and I am, therefore, unable to collect either a botanical 8910.
specimen or its roots.

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G. I. C. P. O.—No. 332 R. & A.—11-4-98.—2,200—W. B. G.